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The Sixth Report in a Series on
Efficiency in Fruit Marketing

IN-PLANT TRANSPORTATION COSTS AS RELATED TO MATERIALS HANDLING METHODS—APPLE AND PEAR PACKING

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TABLE OF CONTENTS

Page

INTRODUCTION 1

TRANSPORTATION LABOR COSTS IN SAMPLE PLANTS 4

ESTIMATING TRANSPORTATION COSTS 7

- Fixed costs 7
- Direct costs 9
- Total costs 9
- Requirements for transportation crew and equipment 11

TRANSPORTATION COSTS IN A MODEL PLANT 14

- The model plant 15
- Transportation costs with hand-truck and fork-truck equipment 16

COST REDUCTION POSSIBILITIES 19

- Changes in equipment for transporting packed fruit 20
  - Fork-truck plant 20
  - Hand-truck plant 22
- Changes in equipment for transporting incoming fruit 25
- Changes in plan of operation for receiving incoming fruit 29
  - Direct movement of fruit to dumper 29
  - Revise floor layout of receiving area 32
- Change in load size 34
- Combining changes for low-cost operation 36

EFFECT OF CHANGES IN COST RATES ON TRANSPORTATION COSTS IN MODEL PLANTS 37

- Changes in price level 39
- Changes in proportion of nonproductive time 41
- Effect of idle equipment 41
- Changes in estimates of use life 43

OWNERSHIP COSTS VERSUS RENTAL COSTS FOR FORK-TRUCK EQUIPMENT 43

OTHER FACTORS AFFECTING CHOICE OF EQUIPMENT 46

SUMMARY 47

APPENDIX A, ESTIMATING REQUIREMENTS FOR TRANSPORTATION CREW AND EQUIPMENT, THE MODEL PLANT 49

- Requirements for trucking operations 52
- Requirements for setoff operation 57
- Estimates of transportation crew and equipment 57

FOREWORD

This report is the sixth in a series aimed at improved efficiency and lowered costs in the local marketing and packing of deciduous fruits. The present report deals with a segment of the packing house operations--the transportation of fruit and materials at the packing house.

In studies of costs in a number of California apple and pear packing plants, the labor cost of in-plant transportation varied from $1.140 to $0.209 per 1,000 pounds of fruit received; these amounts represent, respectively, 16.1 per cent of the total direct labor in the high-cost plant and 3.7 per cent in the low-cost plant. This range in costs suggests that important savings in the cost of in-plant transportation are possible.

This report is designed to aid packing house managers in making decisions as to the adoption of changes in transportation equipment and methods. The report presents time requirements for the performance of various transportation jobs; estimates of season transportation costs in a model packing house operated with a variety of work methods and types of equipment; and an evaluation of the effect on relative transportation costs in hand-truck and fork-truck plants if certain of the rates affecting costs are changed.

These studies were made cooperatively by the Giannini Foundation of Agricultural Economics, California Agricultural Experiment Station, and the Bureau of Agricultural Economics, U. S. Department of Agriculture. They were made under authority of the Research and Marketing Act of 1946.

Efficiency in Fruit Marketing

IN-PLANT TRANSPORTATION COSTS AS RELATED TO MATERIALS HANDLING METHODS--APPLE AND PEAR PACKING

L. L. Sammet[1]

INTRODUCTION

A casual observation of the work performed in packing fresh fruit indicates that much of it consists of moving fruit and materials from one point to another in the packing house. Several different types of equipment are used for this purpose. These include hand trucks, powered trucks (fork trucks and powered hand trucks), and various forms of gravity and powered conveyors. Apple packing plants in the Northwest--and California citrus packing houses--use a floor chain conveyor that will transport lugs or boxes in stacks (Figure 1).

Load capacity varies considerably with the different types of equipment and with the type of material transported. For example, in transporting full field lugs, the load sizes observed varied from 5 to 6 lugs with hand-truck equipment and from 30 to 42 lugs with fork-truck equipment. In transporting empty standard packing boxes, the load sizes observed ranged from 14 to 21 boxes with hand trucks and from 72 to 96 boxes with fork trucks. Observed load sizes for various types of equipment and materials are summarized in Table 1.

The use of radically different types of equipment--such as described above--may result in large differences in costs. The important differences in costs are evaluated in this report.

In the cost comparisons which follow, only the costs of labor and equipment are considered. This ignores an important aspect of the problem--the basic difference in building requirements for the hand-truck and fork-truck plants. In the hand-truck plants, the building usually is of wood frame construction, with a wood floor constructed at truck-bed height. Roof supports are spaced a moderate distance apart, say 20 to 40 feet. The usual construction in the fork-truck plants, however, consists of a concrete slab floor at ground level, concrete sidewalls, and a relatively long-span roof construction, say 75 to 100 feet.

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[1] L. L. Sammet is a Cooperative Agent of the California Agricultural Experiment Station and the Bureau of Agricultural Economics, U. S. Department of Agriculture.

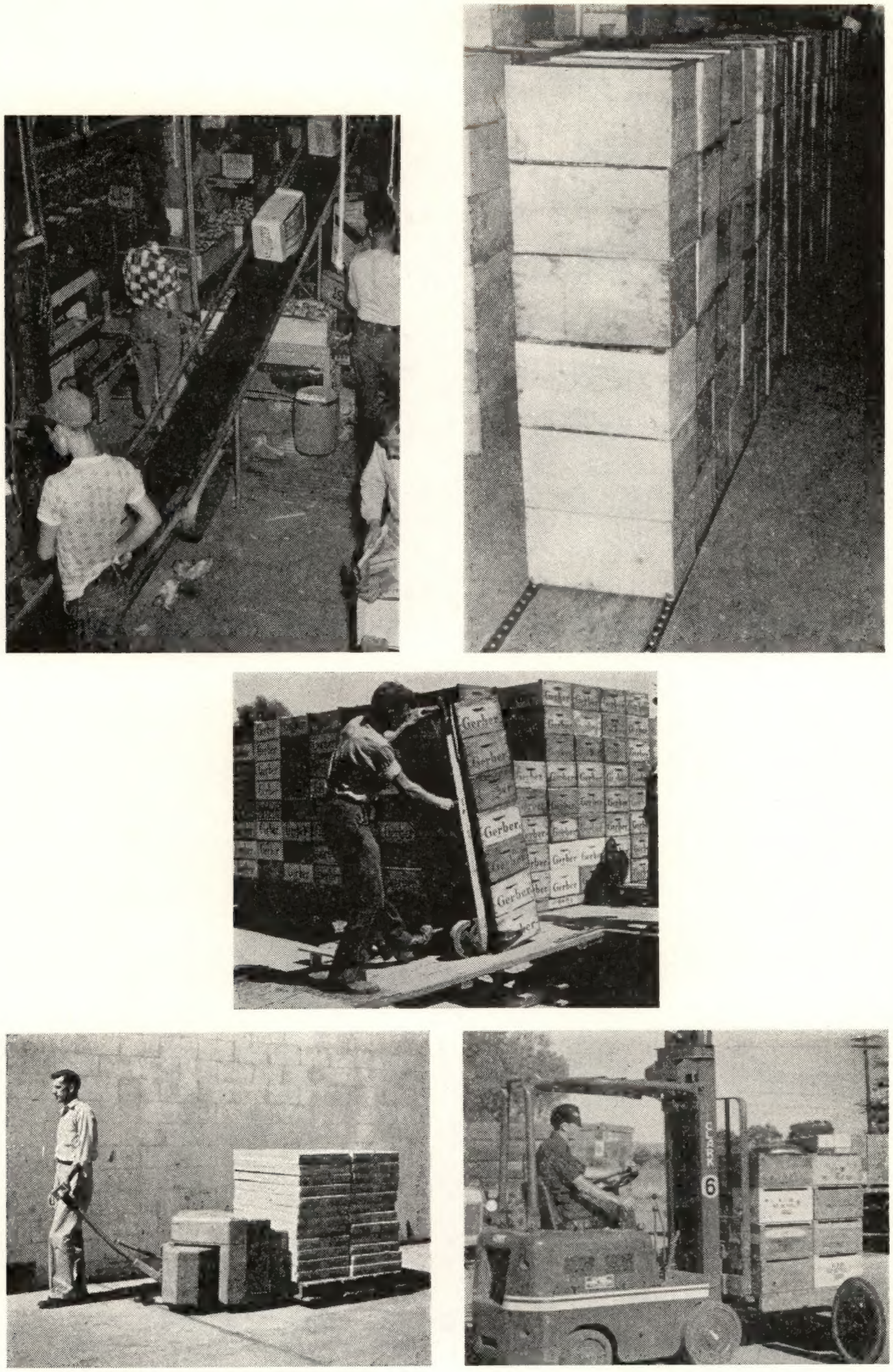

Figure 1. Equipment for transporting fruit and materials in apple and pear packing plants.

Upper left: Power conveyor for packed fruit.

Upper right: Floor-chain conveyor for stacked boxes or lugs.

Center: Hand truck.

Lower left: Powered hand truck.

Lower right: Fork truck.

TABLE 1

Effect of Type of Equipment and Type of Material on Size of Load per Trip

Material moved	Type of equipment: Fork truck or powered hand truck	Type of equipment: Hand clamp truck
Cannery lugs:		
Empty	42 to 54	6 to 7
Full	42	6 to 7
Field lugs:		
Empty	30 to 42	8 to 12
Full	30 to 42	5 to 6
Packed box:		
Los Angeles lug, empty	81 to 150	24 to 32
Los Angeles lug, full	60 to 81	9 to 10
San Francisco lug, empty		10 to 12
San Francisco lug, full	42	6
Standard box, empty	60 to 96	14 to 21
Standard box, full	36 to 48	4 to 5
Shook (pieces):		
Los Angeles lug, bottom	3,000 to 3,500	600[a]
Los Angeles lug, head	600 to 900	150[a]
Los Angeles lug, side	2,500 to 3,500	600[a]
Standard box, bottom	1,500	300[a]
Standard box, head	450 to 600	100[a]
Standard box, side	2,500 to 3,000	500[a]
Standard box, lids	1,800	350[a]

a/ Estimated.

The differences in building design introduce several factors that affect building construction costs and therefore should be considered in a comparison of transportation costs with fork-truck and hand-truck equipment. Factors tending to increase the building cost for the fork-truck operation include the higher unit costs for wall and roof construction in the fork-truck plants and the need for a much larger--and usually better surfaced--area of pavement adjacent to the building for loading and unloading highway trucks. On the other hand, construction costs per unit area for a concrete floor slab at ground level are lower than for a wood floor supported above the ground; also, the roofed area in the fork-truck plant can be smaller because pallet loads of incoming fruit, empty boxes, shook, etc., can readily be stacked several tiers high.

Estimates of replacement costs for buildings indicate that the differences in building requirements for the hand-truck and fork-truck plants balance fairly well from the standpoint of costs. This is particularly true if the building costs are estimated in terms of annual charges which reflect building expenses such as depreciation, repairs, and so on. For example, the 1950 replacement cost of the building for a plant of 45,000 pounds per hour capacity is approximately $62,000 if designed for hand-truck operation, and $73,000 if designed for fork-truck operation. The estimated annual cost, however, is $6,500 for either building.[2]

From the above estimates, it appears that differences in building construction costs--especially when considered in terms of annual fixed cost--are not important. They are omitted from the comparisons that follow. This permits concentration on labor and equipment requirements and costs as affected by transportation equipment and methods.

TRANSPORTATION LABOR COSTS IN SAMPLE PLANTS

The effect of type of equipment on the labor costs of in-plant transportation is illustrated in the summary for 15 California apple and pear packing plants given in Table 2. The table shows for each plant the types of equipment employed in the transportation of incoming fruit, fruit not packed (culls and cannery), and packed fruit. It also shows--in terms of cost per 1,000 pounds of fruit received--the labor cost for transporting each category of fruit, the total cost of transportation labor, and the cost of total direct labor, including supervision. To permit interplant comparisons, the costs were computed on the basis of an 8-hour workday at rates of output typical for each plant and with labor costs in each plant adjusted to reflect uniform wage rates typical for the industry.

In the hand-truck plants, labor costs for transportation varied from $0.645 to $1.140 per 1,000 pounds of fruit received. In the partially mechanized plants, the range was from $0.353 to $0.637 per 1,000 pounds received, and in the fully mechanized plants, the range was from $0.209 to $0.338. Contrasting the high- and low-cost plants, we find transportation labor costs to be more than five times higher in plant L than in plant P.

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[2] For a detailed analysis of building costs, see Building and Equipment Costs--Apple and Pear Packing, Mimeographed Report No. 141. Giannini Foundation of Agricultural Economics, University of California.

TABLE 2

Selected Costs for Total Direct Labor and for In-Plant Transportation Labor in 15 California Apple and Pear Packing Plants[a]

Plant	Type of equipment[b]			Fruit packed relative to total run	Labor cost per 1,000 pounds of fruit run through plant[c]					Transportation labor relative to total labor
					Transportation					
	Incoming fruit	Fruit not packed	Packed fruit		Incoming fruit	Fruit not packed	Fruit packed	Total	Total direct labor	
				per cent	dollars					per cent
					Hand-truck transportation					
A[d]	HT	HT	HT	87.5	.518	.078	.296	.892	6.455	13.8
B[d]	HT	HT	HT	82.8	.413	.072	.513	.998	6.619	15.1
F[d]	HT	HT	HT	57.8	.348	.159	.138	.645	4.870	13.2
L	HT	HT	HT	77.3	.354	.221	.565	1.140	7.089	16.1
N	HT	HT	HT	86.8	.294	.075	.479	.848	6.554	12.9
					Partially mechanized transportation					
H[d]	FT	HT	HT	52.7	.212	.149	.241	.602	4.488	13.4
M	HT	FT	HT	53.4	.218	.139	.280	.637	4.000	15.9
R	HT	FT	HT	54.2	.251	.117	.260	.628	4.559	13.8
T	HT	FT	HT	37.1	.247	.090	.181	.518	3.593	14.4
Q	FT	HT	FT	94.5	.310	.015	.142	.467	6.258	7.5
S	HT	HT	C	65.1	.192	.137	.024[e]	.353	5.298	6.7
					Mechanized transportation					
U	FT[f]	FT	C	84.2	.203	.042	.093[e]	.338	5.038	6.7
P	FT	FT	C	85.7	.142	.037	.030[e]	.209	5.658	3.7
V	FT	FT	FT	65.7	.073	.039	.109	.221	3.880	5.7
W	FT	FT	FT	60.1	.112	.034	.166	.312	4.264	7.3

[a] Computed on the basis of 8-hour days, with typical hourly rates of output. Labor costs adjusted to reflect uniform wage rates typical for the industry. Costs adjusted to eliminate labor costs in cold storage or precooling operations.

[b] Abbreviations: HT = hand truck; FT = fork truck; C = power conveyor.

[c] All direct labor, including packing, boxmaking, and labeling; also, direct supervision.

[d] Apple packing plants.

[e] Labor cost for diverting fruit of different size grade, different label, or different type of package to separate conveyors leading to different cars, or to route a portion of the fruit directly to cars, with the remainder going to cold storage or to a precooler.

[f] Part of receiving operations performed by hand truck.

Expressed in terms of the transportation labor cost per standard box packed in these plants, this range is from $0.012 to $0.071 per standard box. Comparisons equally striking can be made for the transportation costs applicable to the cannery and cull fruit.

Compared to total direct labor, the labor cost for transportation amounted to 16.1 per cent in plant L and only 3.7 per cent in plant P.

From Table 2, it appears that mechanization of the transportation operations can result in large savings in labor cost. Before reaching any conclusions as to the relative economy of the different types of equipment, however, many additional factors must be considered. An obvious and important factor is the cost of equipment. To purchase a fork-lift truck requires roughly 50 times the outlay required to purchase a hand truck. This difference, as well as differences in labor and equipment operating costs, must be taken into account in a comparison of costs and efficiency in their use. Other important factors include: (a) the plant layout as it affects transport distance; (b) the size of load transported per trip; (c) the amount of inactive time--that is, the time spent in rest periods and in unavoidable delays--and a closely related factor, the "indivisibility" of workers and equipment units; (d) whether cold storage or precooling operations are performed by the packing house; (e) the effect of the type of transportation equipment on the type of buildings required and on their cost (see page 1); and (f) the length of the packing season and the hourly rate at which fruit must be handled. If comparisons were made in terms of actual costs rather than "standardized" costs such as presented in Table 2, differences in wage rates in the various plants and day-to-day variations in rate of output in each plant would also be important.

Thus, many of the factors affecting transportation costs relate to conditions within a particular plant. The nature of the variations between plants makes it very difficult to judge their effect on actual costs. Conclusions drawn from plant cost records may easily be misleading, even when the costs are standardized to the extent that they are in Table 2. For these reasons, the comparisons of in-plant transportation costs which follow are made by means of estimates of costs with different types of equipment when used in typical, or "model," plants.

ESTIMATING TRANSPORTATION COSTS

There are two categories of transportation costs. One includes the annual charges--or, fixed costs--for equipment, which are to a large extent independent of hours of use per season. A second category includes the costs directly associated with use, such as the cost of operating labor and fuel. In the following discussion, data regarding fixed costs are presented, and this is followed by the development of methods for estimating direct costs. Estimates of direct and fixed costs are then combined to obtain estimates of total season transportation costs.

Fixed Costs

Fixed costs for equipment might be described as the "costs of ownership." These include taxes, insurance, repairs, interest on the investment and depreciation. A precise value for the fixed costs is impossible to secure before the equipment is finally disposed of. There is a large degree of uncertainty as to the physical life of the equipment, the possibility that it may become obsolete before actual wear-out, possible salvage value at the end of the use period, and the necessity of forecasting appropriate rates for taxes and other costs.

In actual accounting practice, moreover, depreciation costs usually are lumped together with allowances for the normal risks relating to future trends in costs and product prices. The cost rate thus obtained forms the basis of decisions as to whether investment in new equipment should be made; it often is the rate actually charged once the new equipment is acquired.

If the costs of equipment are associated with actual use life--that is, leaving for a separate accounting any charges attributable to risks--depreciation rates appropriate for the types of equipment used for in-plant transportation might appear as in Table 3. In this table, depreciation rates are computed from the estimated service life of the equipment and are given as the percentage of the original value that is written off each year. Similarly, percentage rates commonly used for insurance, interest, and taxes are given. A percentage rate for a part of the repair expenses also is included as a part of the annual fixed charge.3/

3/ Repair costs are properly attributable to both time and use. For example, the deterioration of hydraulic hose, electrical wiring, and batteries, and all forms of corrosion are to a large extent a function of time. In fact, some such types of deterioration are accelerated by idleness. Other forms of wear increase with use. In this report, a fixed annual repair cost is estimated as indicated above. In addition, a direct repair expense is included at the rate of 0.5 per cent of the replacement cost per 100 hours' use (see Table 4.)

TABLE 3

Annual Fixed Cost of In-Plant Transportation Equipment, as a Percentage of Replacement Cost

Type of equipment	Estimated service life[a]	Annual charge as a percentage of replacement cost			
		Depreciation	Repairs[b]	Insurance, interest, taxes[c]	Total
Conveyor:					
Gravity	20	5.0	1.5	5.0	11.5
Powered	15	6.7	1.5	5.0	13.2
Hand truck	15	6.7	1.5	5.0	13.2
Fork truck	10	10.0	1.5	5.0	16.5
Powered hand truck	10	10.0	1.5	5.0	16.5
Pallets	10	10.0	1.5	5.0	16.5

[a] Estimated (actual service) life, taking account of seasonal operation (1 to 3 months per year). Assuming no salvage value at end of use period.

[b] An additional amount for repairs is included with the direct costs. This direct repair cost is estimated as 0.5 per cent of replacement cost per 100 hours of equipment use per season.

[c] Insurance 1.0 per cent; taxes 1.0 per cent; interest 3 per cent (interest at 3 per cent equal to approximately 5 per cent on undepreciated balance).

When applied to the replacement cost, the rates given in Table 3 provide an estimate of fixed costs for equipment. For example, the estimated replacement cost of a gas-engine fork truck of 4,000-pound capacity at the 1950 price level is approximately \$3,300, and the replacement cost of the necessary pallets would approximate \$440.[4/] Using the percentage annual charge from Table 3, the estimated annual fixed cost for a fork truck and the associated pallets would be:

Fork truck:	\$3,300 x 0.165 =	\$545
Pallets:	440 x 0.165 =	73
Total:		\$618

Estimated replacement costs and annual fixed charges for various types of transportation equipment are summarized in Table 4.

Direct Costs

Direct costs for the transportation equipment include the labor cost of the operator, repair costs directly attributable to use, and--with powered equipment--operating costs such as gasoline or electric power. These costs vary with the kind of equipment and the particular plant. The rates used are typical of those observed in the plants studied, except for repair costs. Data on repair costs are very inadequate, and direct repair costs are estimated as 0.5 per cent of the replacement cost per 100 hours of use. This estimate of direct repair cost is in addition to the provision for repair expense as a part of the fixed annual charge given in Table 3. Direct costs rates for various types of in-plant transportation equipment are summarized in Table 4. For example, direct costs per hour of operation for a gas-engine fork truck of 4,000-pound capacity are given as: labor, \$1.30; gasoline and oil, \$0.15; direct repair costs, \$0.165; total direct cost, \$1.615 per hour.

Total Costs

Total transportation costs per season for a given type of equipment are the sum of the annual fixed charge for the equipment and the total direct cost for the season. For example, the total season costs for hand-truck or fork-truck equipment are estimated **on page 11** for seasons of 100 and 300 hours in length:

[4/] Equivalent to approximately 125, 40" x 45" pallets. This provides about 13 pallets per 1,000 pounds of fruit run per hour. If the frequently used practice of continuous loading of packed fruit in cars is assumed, no pallets are "tied up" in cold storage or precooling operations, and--assuming that pallets for cannery fruit are furnished by the cannery firm--this number of pallets would be adequate for 1½ to 2 days' run without reuse of any field pallets.

TABLE 4

Direct and Annual Fixed Cost of In-Plant Transportation Equipment

Item	Fixed costs			Direct costs			
	Replacement cost new[a]	Annual charge as a percentage of cost new[b]	Annual charge	Repairs[c]	Power	Labor	Total
	dollars	per cent	dollars	dollars per hour			
Conveyor:							
Side wheel, gravity, 8-foot section	25	11.5	2.90	0.001	--	[d]	0.001
Roller, 10-foot section	58	11.5	6.70	0.003	--	[d]	0.003
Power, 12-inch belt on steel rolls, 20-foot section	480	13.2	63.40	0.024	0.02[e]	[d]	0.044
Power, 12-inch belt on steel rolls, 100-foot section	1,200	13.2	158.40	0.060	0.03[e]	[d]	0.090
Power, 12-inch belt on wood rolls, 20-foot section	430	13.2	56.80	0.022	0.02[e]	[d]	0.042
Power, 12-inch belt on wood rolls, 100-foot section	970	13.2	128.00	0.048	0.03[f]	[d]	0.078
Hand truck, each	66	13.2	8.70	0.003	--	1.25	1.253
Fork truck (4,000-pound capacity, gas engine), each	3,300	16.5	544.50	0.165	0.15[f]	1.30	1.615
Powered hand truck, each	1,600	16.5	264.00	0.080	0.10[f]	1.30	1.480
Pallets, each	3.5	16.5	0.60	0.0002	--	--	0.0002

[a] Approximate cost installed, 1950 price level.

[b] See Table 3.

[c] Direct repair cost is estimated as 0.5 per cent of replacement cost per 100 hours of equipment use per season.

[d] Although no labor cost is incurred in operating a conveyor, some associated labor must be considered in analyzing costs. Thus, transportation of packed fruit by conveyor may require the services of a "conveyor man" to route fruit at a switching point to several different conveyors (see pages 5 and 25). Also, "set off packed fruit" at a lidding machine is a labor cost element that enters into the comparison of costs with conveyors for packed fruit and other types of equipment.

[e] Cost of electric power. Does not include labor cost for hand transfer of packed boxes to, or from, conveyor.

[f] Includes cost of gasoline and lubricating oils.

Item	Total season cost			
	Fork truck		Hand truck	
Hours of operation per season	100	300	100	300
Annual fixed charge	$618[a]	$ 618[a]	$ 9	$ 9
Direct cost per season:				
Labor	130	390	125	375
Repairs	32	95	--	1
Total cost per season	$780	$1,103	$134	$384

[a] Including cost of pallets.

The total season cost divided by hours of operation per season gives the total cost per hour. In the fork-truck plant, the total cost with 100 hours' operation per season is $7.20 per hour per truck and with 300 hours' operation per season is $3.70 per hour per truck. In the hand-truck plant, the hourly costs are, respectively, $1.35 and $1.28. These figures show that for a given type of equipment the total cost per hour decreases as the length of season increases, also, that the difference between the cost per hour for fork trucks and hand trucks decreases as hours of operation per season increase. These effects are the result of spreading the fixed costs over a larger number of hours of operation as the length of season increases.

Requirements for Transportation Crew and Equipment[5]

Only two types of jobs are considered in the analysis that follows. These are the setoff and stacking of packed boxes after lidding and the operation of various kinds of trucking equipment.

In estimating the costs for the trucking operations, we must consider the requirements and costs for equipment as well as for labor. Both of these are affected by the type of equipment used, the size load carried per trip, and the distances traveled. For each type of truck, the initial step is to estimate the labor required to transport a given quantity of fruit. The procedure for hand-truck equipment is illustrated as follows.

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[5] For a more complete presentation of procedures and data for estimating transportation crew requirements and costs, see Appendix A.

Suppose that fruit is packed in standard boxes of 48 pounds net weight each at the rate of 30,000 pounds per hour. With a hand truck, the packed boxes are transported in stacks 5 boxes high a distance of 35 feet to a temporary storage. Studies of hand trucking in actual plants indicate that an average time of 0.529 minutes would be required per trip. With 240 pounds transported per trip, 4.17 trips are required to transport 1,000 pounds of fruit; and the labor required is 2.20 man-minutes per 1,000 pounds. To transport 30,000 pounds of fruit per hour would thus require 66 man-minutes, or slightly more than the capacity rate of one trucker.

A similar procedure is followed in estimating the labor requirements for the entire plant. First, the requirements for each element of the transportation operations are estimated. The sum of the labor requirements for individual operations then represents the requirements for the entire plant. The results of this procedure are illustrated in Table 5, in which estimates are given of the trucking labor required in a typical hand-truck plant. In this plant, the rate of operation is assumed to be 40,000 pounds of fruit run per hour, of which 30,000 pounds per hour are packed, and the remainder consists of cannery fruit and culls.

TABLE 5

Estimated Net Trucking Labor Requirements for In-Plant Transportation in a Hand-Truck Plant of 40,000 Pounds per Hour Capacity

Operation	Time required per 1,000 pounds of fruit run
	minutes
Receiving: unload grower's truck and transport full field lugs to dumper via temporary storage; transport empty lugs to grower's truck via temporary storage	8.12
Cannery and cull fruit: unload truck and transport empty lugs to cannery station via temporary storage; transport full lugs to truck via temporary storage	1.74
Packed fruit: transport packed fruit to truck or car via temporary storage	3.55
Shook and boxes: transport shook to boxmaker and empty boxes to storage and return	0.39
Total time per 1,000 pounds run	13.80

In Table 5 each job grouping involves several individual time estimates. The estimate for receiving, for example, represents the sum of four separate items: unloading the grower's truck and transporting the incoming fruit to a temporary storage; transporting fruit from the temporary storage to the dumper; transporting empty field lugs from the dumper to a temporary storage; and loading the grower's truck with empty lugs. Estimates for the remaining job categories involve a similar procedure. The sum of such estimates for individual operations is 13.8 man-minutes per 1,000 pounds of fruit run.

In addition to the jobs specified in the above estimate, there are miscellaneous transportation jobs, such as hauling lids and wraps, unloading shook, and moving between different transportation jobs that are too irregular and too minor to estimate in detail. Studies of materials handling in the packing houses indicate that this miscellaneous work amounts to roughly 10 per cent of the work included in the detailed estimate given above. With this addition to the above estimate, the total transportation labor requirements are 15.2 man-minutes per 1,000 pounds of fruit run. This, however, is the net working time to which must be added allowances for rest periods and for unavoidable delays. Based on the usual allowance of two 10-minute rest periods per 8-hour day, the rest time amounts to 4.2 per cent of the total working time. The unavoidable delay is difficult to estimate and varies from plant to plant. In the studies of transportation in different plants, the actual delay observed for transportation workers ranged from 15 to 40 per cent of the total work time. If 15 per cent unavoidable delay is taken as a practical minimum and this figure is combined with the allowance for rest, the total unproductive time is 19.2 per cent of the total work time. Using a rounded figure of 20 per cent total unproductive time, the trucking labor required to handle 40,000 pounds of fruit per hour in this example then is 760 man-minutes per hour. This is equivalent to the employment of about 13 truckers.

A similar procedure is followed in estimating the labor required to set off and stack packed boxes after lidding. For this job, the net productive time indicated by studies in several packing houses is 0.105 minutes per box. To set off 1,000 pounds of fruit in standard boxes of 48 pounds net weight each requires (1,000/48)0.105 = 2.19 man-minutes. This is net productive time. If the allowance for rest and unavoidable delay is 20 per cent of the total work time, the gross labor required is 2.73 man-minutes per 1,000 pounds. For a rate of packing of 30,000 pounds of fruit per hour, the total setoff labor then is (30 x 2.73) = 82 man-minutes per hour. In this case, the labor

actually supplied is two workers, unless it is possible to employ part of the setoff worker's time on some other operation--for example, supplying lids to the lidder, applying shipping stamps, etc.

At the cost per worker previously noted of $1.25 per hour, the cost of the setoff operation for packed fruit in this example is $2.50 per hour of plant operation, assuming that two workers are assigned full time.

From the estimate of transportation requirements given above, an estimate of total season cost for the trucking and setoff operations can be made. Using the cost rates given in Table 4 and assuming 300 hours of operation per season, the estimated season costs would be as follows:

Direct costs	
Setoff labor (2 setoff men at $1.25 each):	$ 750
Trucking labor (13 truckers at $1.25 per hour each):	4,875
Equipment repairs (13 hand trucks at $0.003 per hour each):	13
Fixed costs	
(13 hand trucks at $9.00 per year per truck)	117
Total cost	$5,755

Similarly, total costs can be estimated for different lengths of season and for different types of equipment

TRANSPORTATION COSTS IN A MODEL PLANT

As previously noted, comparisons of transportation costs with different types of equipment are made in this report primarily in terms of estimates of cost in typical, or "model," plants. The cost estimates for the various methods are developed, in the manner just described, from basic time requirements for various operations and from estimates of the fixed and direct costs applicable to various types of equipment.

The models used are designed as examples of relatively efficient plants but do not represent an "ideal" plant organization. They consist of a basic plant organization in which the arrangement of equipment, the types of operations, and certain other factors are standardized.[6] These elements are then

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[6] For a detailed specification of the model plant, see Appendix A.

held constant, while certain variations in transportation methods are studied to determine their effect on costs. The design of the model follows closely that of typical operating plants and reflects the requirements for in-plant transportation represented in the simplified process diagram, Figure 2, page 18.

The Model Plant

Selecting only the transportation jobs shown outside the shaded area in Figure 2, the standardized, or "model," plant on which the cost comparisons are based may be specified as follows:

1. All incoming fruit is unloaded and transported to a temporary storage, then to the dumping station; empty lugs (stacked by the dumper) are transported to a temporary storage, then to the grower's truck.
2. In a similar manner, empty lugs are transported from the cannery truck to storage, then to the cannery setoff, from which the full lugs are transported first to storage, then to the cannery truck.
3. Packed fruit is set off and stacked at the lidder, then is trucked to a railroad car or highway truck for loading.
4. Comparable operations are carried on for shook, empty packing boxes, and other packing materials.

The analysis does not include the transportation jobs shown within the shaded area in Figure 2. The operations omitted are the conveying of fruit from the dumping station to the sorters and from the sorters to the packers as this is a highly standardized operation in all plants. On the same ground, we omit the conveying of packed fruit from the packers to the lidder. Another omission is the delivery of empty boxes to the packers. This operation will be considered in a later report.

The transportation operations included in the model are illustrated in Figure 2 and are specified in detail in Table B of the Appendix. For example, in regard to unloading the grower's truck, the average transportation distance to the temporary storage is specified as 50 feet, and the size of load is specified as 6 lugs per trip. For the same operation, but with fork-truck equipment, the distance is given as 100 feet and the number of boxes hauled per trip as 36. Similarly, load sizes and transport distance are specified for the other operations.

The proportion of fruit handled as packed fruit is specified as 75 per cent of the total amount received, with 25 per cent diverted to cannery and culls. A further provision is that 80 per cent of the empty packing boxes go directly by conveyor from the boxmaker to the point of supply to the packers,

while 20 per cent of the empty boxes are transported to a temporary storage and later returned to the packer supply point. In the model, the latter quantity of boxes is all that is considered in estimating transportation costs as those conveyed directly from the boxmaker to the packer supply point involve no additional transportation labor. In addition, costs estimates derived from the model include allowance for a number of miscellaneous transportation jobs, none of which individually are important enough to detail.

To simplify the analysis, it is assumed that all the fruit is packed in standard boxes. This model plant forms the basis of the analysis that follows. Estimates of transportation costs first are made for the model as specified. Variations as to type of equipment are then introduced, and their effect on costs is examined.

Throughout, the analysis is based on operation of the model plant for pear packing, but with slight modification the costs would apply to apple packing. The sizes of the various containers used are roughly the same for both kinds of fruit, and load sizes with the transportation equipment are about the same. With lighter net weights per box for apples, however, more trips are required to transport a given weight of fruit. This means that, on a weight basis, the costs of in-plant transportation in apple packing plants are slightly higher than in pear packing plants. In general, the level of costs per 1,000 pounds of fruit run would be about 10 per cent higher in the apple packing plants, although on a per box basis, the costs are about the same in both apple and pear packing plants. The general indications as to the relative costs with different types of equipment also are about the same in apple and pear packing plants.

Transportation Costs with Hand-Truck and Fork-Truck Equipment

Estimates of transportation costs for two variations on the model plant are presented in Table 6 and Figure 3. One variation involves the use of fork-truck equipment, the other, the use of hand-truck equipment. Annual fixed costs and direct costs per hour of operation are given for both types of equipment for rates of plant operation ranging from 20,000 to 80,000 pounds of fruit run per hour. In the fork-truck plant, the annual fixed costs are $1,410 for a rate of operation of 20,000 pounds per hour and $4,850 for a rate of operation of 80,000 pounds per hour. Direct costs in the fork-truck plant are $5.30 per hour of operation when fruit is run at the rate of 20,000 pounds per hour and $16.90 when the rate of plant operation is 80,000 pounds

per hour. The corresponding range in direct costs in the hand-truck plant is from \$10.00 to \$36.40 per hour of plant operation.

TABLE 6

The Effect of Hand-Truck and Fork-Truck Equipment on Transportation Costs in the Model Plant

Type of equipment	Rate of operation per hour	Annual fixed costs for equipment[a]	Direct costs per hour of operation
	1,000 pounds	dollars	
Fork truck	20	1,410	5.30
	40	2,570	9.20
	60	3,700	13.05
	80	4,850	16.90
Hand truck	20	60	10.00
	40	120	18.85
	60	175	27.60
	80	230	36.40

a/ Estimated as a percentage of replacement cost, 1950 price level. See Table 3 for percentage rates.

The transportation cost estimates in Table 6 show large differences between the annual fixed costs in the hand-truck and fork-truck plants. This applies also to the direct costs. For costs to be equal with either system, the excess of fixed costs in the fork-truck plant must be balanced by savings in direct costs when fork trucks are used. For example, with a rate of plant operation of 40,000 pounds per hour, the annual fixed costs in the fork-truck plant exceed those in the hand-truck plant by \$2,450, while the saving in direct costs with the fork-truck equipment is \$9.65 per hour. To accumulate savings equal to the difference in annual fixed costs requires operation for approximately 2,450/9.65 = 255 hours per season. At this length of operating season, the two types of equipment "break even" as to cost.

Relative transportation costs with fork-truck and hand-truck equipment in the model plant are shown graphically in Figure 3 for a rate of plant operation of 40,000 pounds per hour. In this diagram total season transportation costs are given on the vertical scale in relation to hours of plant operation per season, which are shown on the horizontal scale. The annual fixed costs for each type of equipment are indicated by the point at which the sloping cost line intersects the vertical scale, while the direct costs in each case are represented by the slope of the cost line. Thus, the steep slope of the

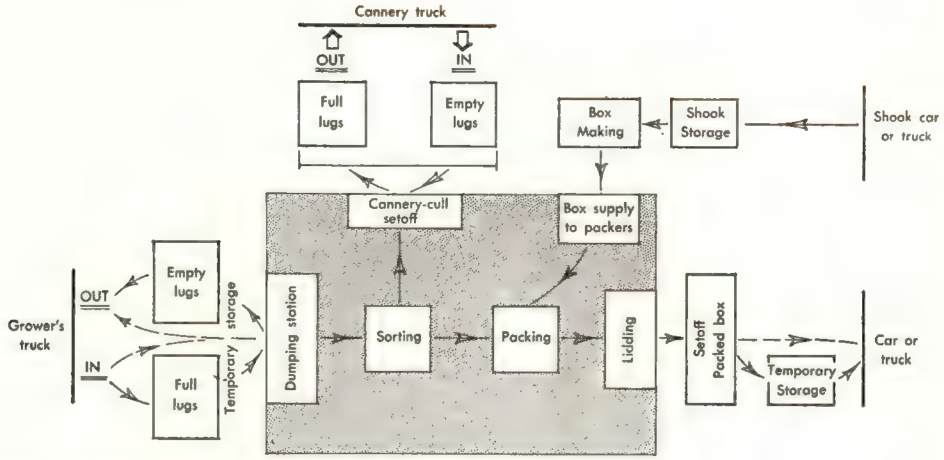


Figure 2. Process chart for apple and pear packing plants.

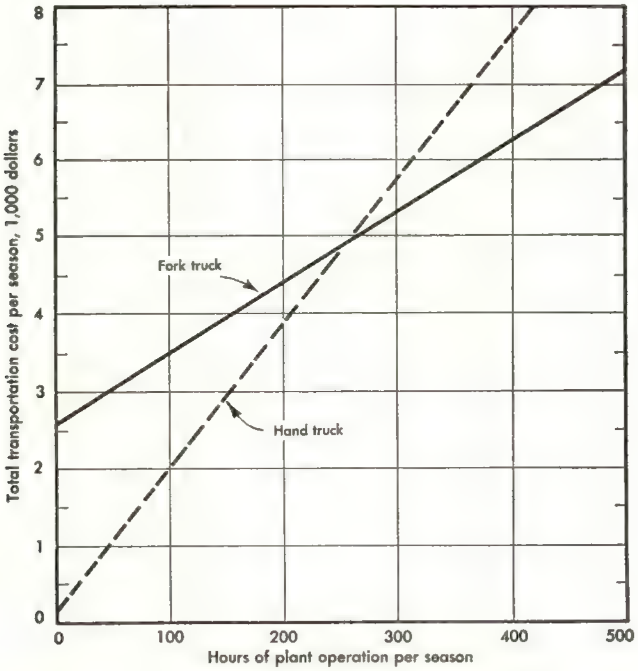


Figure 3. Effect of length of season on total transportation costs in the model plant, using fork-truck or hand-truck equipment. (Rate of plant operation, 40,000 pounds per hour.)

cost line for the hand-truck plant relative to that for the fork-truck plant reflects the difference in direct costs per hour with the two types of equipment. The break-even point is indicated by the intersection of the two cost lines, as at this point season total transportation costs read on the vertical scale are the same for either type of equipment.

By reading total season transportation costs from Figure 3 for different lengths of season, an estimate of savings possible through the use of one type of equipment in contrast with the other can be made. With only 100 hours' operation per season, for example, the chart indicates that the season total cost with fork-truck equipment is approximately $3,500 but is only $2,000 with hand-truck equipment. For this length of operation per season, therefore, the use of fork-truck equipment instead of hand-truck equipment would result in a "loss" of $1,500 per season. With 400 hours' operation, however, the situation is reversed, and the use of fork-truck equipment would result in an estimated annual saving of approximately $1,400.

Comparisons such as the above can be made for other rates of plant operation from the cost data given in Table 6. For different rates of plant operation, the level of costs for a given length of season will be quite different. The break-even point also will shift, but not by a large amount. With a rate of plant operation of 40,000 pounds per hour, for example, the break-even point is at 255 hours operation per season. With rates of operation 20,000 or 60,000 pounds per hour, the break-even points are, respectively, at 285 and 240 hours operation per season.

COST REDUCTION POSSIBILITIES

The costs for in-plant transportation in the model plant that are presented in Table 6 apply to a well-planned, relatively efficient organization. Nevertheless, some adjustments can be made that will reduce costs. As the organization of the model plant is similar to that commonly found in the industry, cost-reducing changes in the model will indicate the kinds of adjustment that should be profitable in actual plants.

These adjustments include a reduction in nonproductive time through better coordination of crew size with the rate of plant operation; change in the plant layout so as to reduce transportation distances; the substitution of different kinds of equipment; change in the pattern of movement for fruit and materials so as to reduce the amount of handling--as, for example, transporting incoming fruit directly to the dumping station rather than via a

temporary storage. Some such changes involve only a better adjustment within the existing plant, while others require alterations to the plant.

In Tables 7 to 12, which follow, cost estimates are given for transportation in the model plants after the introduction of specified changes. The effects of these changes are examined by comparison of costs in the revised plants with those for the original model.

Changes in Equipment for Transporting Packed Fruit

Fork-truck plant.--Consider first the effect on season transportation costs in the model fork-truck plant if the methods of handling packed fruit are modified as follows:

(M) Model plant--packed fruit transported by fork truck to car via temporary storage.

(A) Model plant--except that the packed fruit is transported by a power conveyor directly from the lidder to the car or highway truck, thus eliminating the operation "set off and stack packed boxes" and also eliminating the transportation of packed fruit by fork truck. (Note: In the cost estimates, allowance is made for a "conveyor man" whose task is to route boxes from a given lot of fruit /or fruit of a particular size7 to designated cars, to set off fruit to temporary storage during interruptions in carloading work, etc.)

(B) Model plant--except that the packed fruit is transported directly to the car by fork truck rather than via a temporary storage.

(C) Model plant--except that packed fruit is first set off from a gravity conveyor leading from the lidding machine and classified by lot or by size of fruit, as desired. Later, the fruit so classified is set on a parallel power conveyor leading to the car. To facilitate this operation, the fruit is set off on pallets which rest on gravity floor conveyors, thus allowing the loaded pallet to be pushed to a point adjacent to the power conveyor. This procedure permits the accumulation of a substantial quantity of fruit in a given size or lot before it is finally routed to the car.

TABLE 7

Effect of Variations in the Method of Transporting Packed Fruit on Total Season Transportation Costs in the Model Fork-Truck Plant

Method	Rate of operation per hour	Annual fixed costs for equipment[a]	Direct costs per hour of operation
	1,000 pounds	dollars	
(M) Model plant--packed fruit transported by fork truck to temporary storage, then to car	20	1,410	5.30
	40	2,570	9.20
	60	3,700	13.05
	80	4,850	16.90
(A) Model plant--except packed fruit transported direct from lidder to car by conveyor	20	1,340	4.55
	40	2,475	7.20
	60	3,495	9.70
	80	4,520	12.25
(B) Model plant--except packed fruit transported direct to car by fork truck	20	1,305	5.05
	40	2,380	8.65
	60	3,435	12.25
	80	4,490	15.85
(C) Model plant--except packed fruit set off at lidder and classified, then to car by conveyor	20	1,365	6.35
	40	2,510	10.65
	60	3,545	14.85
	80	4,585	19.15

[a] Estimated as a percentage of replacement cost. See Table 3 for percentage rates.

From the standpoint of shipping procedures, all of the above methods are essentially the same except that in method A transporting fruit directly to the car by conveyor does not permit classifying the fruit if the output of packed fruit is not large enough to warrant loading more than one car at a time. In other words, if only one car is loaded at a time, the fruit must be loaded "house run."

Estimates of the fixed costs for equipment and for the direct costs--labor and power--for the model plant and for the three variations are given in Table 7. Note that, for a given rate of plant operation, there is little difference in fixed costs for any of the four methods but that considerable difference is shown in the direct costs per hour. Consider, for illustration, the estimated costs for a plant operating at the rate of 40,000 pounds per hour. Compared with the model plant, method A would result in a saving in direct costs of $2.00 per hour of operation. A smaller saving--$0.55 per

hour of operation--is indicated in comparing the model plant and method B. Direct costs with method C prove to be higher than in the model plant by $1.45 per hour.

These relationships are shown graphically in Figure 4. Costs with method C are higher than in the model plant, regardless of the length of season, while costs with methods A and B are lower than in the model plant. With 300 hours' operation per season, a change from the model plant to method A would result in savings of approximately $695 per season, while a change to method B would result in savings of about $355 per season. A change to method C would yield a "loss" of about $375 per season, the savings through use of the conveyor to transport the packed fruit to the car being outweighed by the additional labor required to transfer the packed boxes from the temporary pallet storage to the conveyor.

Relationships similar to the above can be derived from the data in Table 7 for other rates of plant operation.

Hand-truck plant.--The handling of packed fruit in the hand-truck plant has been analyzed in a similar manner, and the results are summarized in Table 8 and Figure 5. Six different methods are compared as follows:

(M) Model plant--packed fruit transported to car via temporary storage by hand truck.

(D) Model plant--except that packed fruit is transported directly from the lidder to the car by conveyor.

(E) Model plant--except that packed fruit is transported directly to the car by powered hand truck.

(F) Model plant--except that packed fruit is transported directly to the car by hand truck.

(G) Model plant--except that packed fruit is transported via temporary storage by powered hand truck.

(H) Model plant--except that packed fruit is set off at the lidder and classified then set on a conveyor to the car. (The method is the same as that described previously for method C.)

Estimates of the fixed costs and direct costs associated with these methods of handling packed fruit in the hand-truck plant are given in Table 8. At a rate of plant operation of 40,000 pounds per hour, the annual fixed costs range from $105 with method F to $425 with method G. Two of the revised methods result in fairly substantial reductions in direct costs. With a rate

TABLE 8

Effect of Variations in the Method of Transporting Packed Fruit on Transportation Costs in the Model Hand-Truck Plant

Method	Rate of operation per hour	Annual fixed costs for equipment[a]	Direct costs per hour of operation
	1,000 pounds	dollars	
(M) Model plant--packed fruit transported to temporary storage, then to car by hand truck	20	60	10.00
	40	120	18.85
	60	175	27.60
	80	230	36.40
(D) Model plant--except packed fruit transported direct to car by conveyor	20	160	8.00
	40	380	14.20
	60	485	20.30
	80	595	26.40
(E) Model plant--except packed fruit transported direct to car by powered hand truck	20	275	9.25
	40	390	16.55
	60	525	23.70
	80	640	31.05
(F) Model plant--except packed fruit transported direct to car by hand truck	20	60	9.60
	40	105	17.95
	60	165	26.25
	80	220	34.60
(G) Model plant--except packed fruit transported to temporary storage, then to car by powered hand truck	20	305	9.55
	40	425	17.10
	60	635	24.65
	80	800	32.20
(H) Model plant--except packed fruit set off at lidder and classified, then to car by conveyor	20	175	9.75
	40	400	17.60
	60	505	25.45
	80	620	33.25

a/ Estimated as a percentage of replacement cost. See Table 3 for percentage rates.

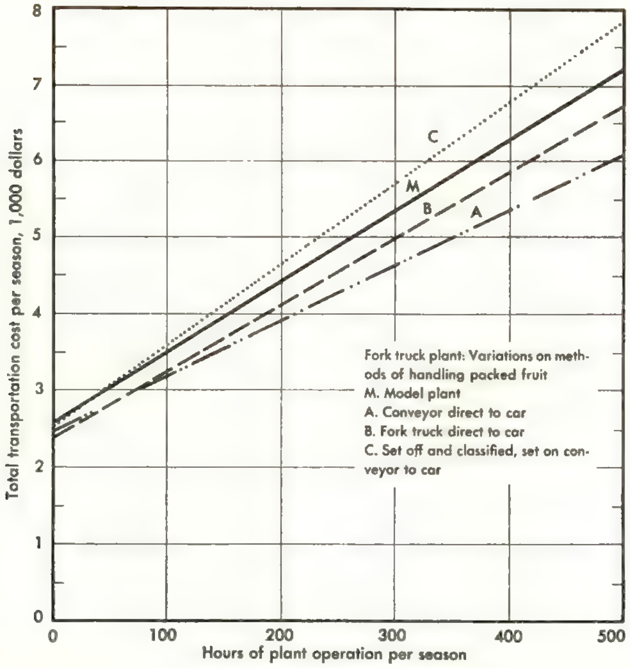


Figure 4. Effect of variations in the method of transporting packed fruit on season total transportation cost in the model fork-truck plant. (Rate of plant operation, 40,000 pounds per hour.)

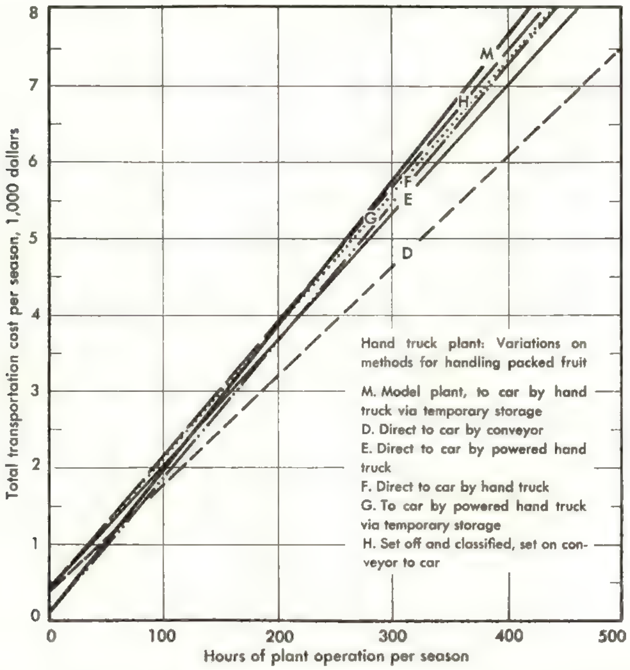


Figure 5. Effects of variations in method of transporting fruit on season total transportation costs in in the model hand-truck plant. (Rate of plant operation, 40,000 pounds per hour.)

of operation of 40,000 pounds per hour, a shift from the model plant to method D would save $4.65 per hour of plant operation, while a shift from the model plant to method E would save $2.30 per hour.

The cost relations for the various methods are shown graphically in Figure 5 for a rate of plant operation of 40,000 pounds per hour. Figure 5 indicates that, from a cost standpoint, there is little difference between the model plant and methods E, F, G, and H. Fixed costs in the latter methods are higher than in the model plant, while direct costs with the revised methods are somewhat lower. As a result, costs are slightly lower in the model plant if the operating season is short; the balance swings in favor of methods E, G, and H as the length of season extends beyond 200 to 300 hours. Method F results in small savings for any length of season. Method D shows more promise. Fixed costs are higher, but direct costs are substantially lower than in the model plant. With 300 hours of operation per season, the indicated savings are approximately $1,135. Similar results can be demonstrated for other rates of plant operation.

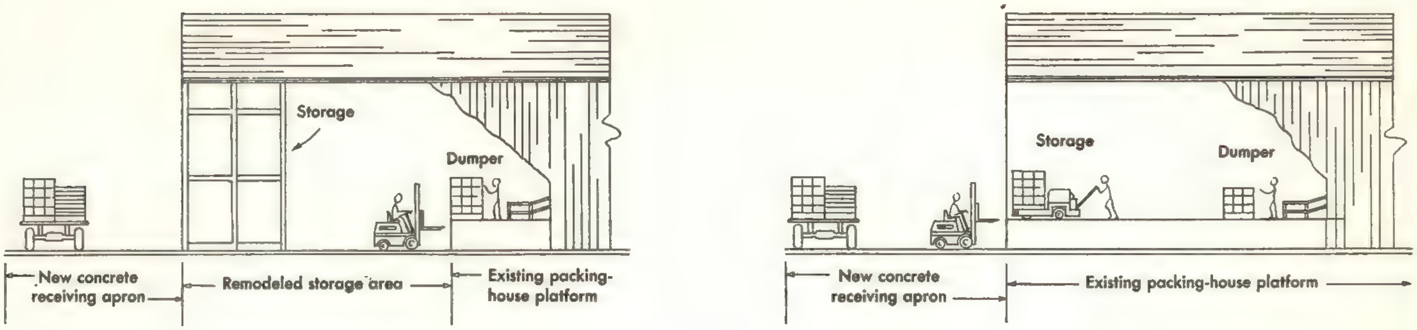
Changes in Equipment for Transporting Incoming Fruit

Similar studies of cost reduction possibilities in the transportation of incoming fruit and cannery fruit are summarized for the model hand-truck plant in Table 9 and in Figure 7. Six different methods are considered. Each involves modification of an existing hand-truck plant. In some instances, this requires alterations to the existing building, although the alterations do not involve changes in the plant "model." No variations in transportation equipment for the receiving operations in the fork-truck plant are considered.

The variations considered in transportation methods in the receiving operations are as follows:

(M) Model plant--incoming and cannery fruit handled with hand-truck equipment.

(I) Model plant--except that cannery fruit is handled with fork-truck equipment. This change requires the addition of a concrete loading apron and some remodeling of the building to provide storage space accessible to the fork truck. The annual cost of these changes is included in the estimate of fixed cost.


Storage
Dumper
New concrete receiving apron
Remodeled storage area
Existing packing-house platform
Storage
Dumper
New concrete receiving apron
Existing packing-house platform

(A) Hand truck plant remodeled to permit incoming fruit to be handled with fork-truck equipment.

(B) Hand truck plant, with incoming fruit handled with fork truck and powered hand truck.

Figure 6. Rearrangement of receiving area in hand-truck packing house to permit use of fork-truck and powered hand-truck equipment for the transport of incoming or cannery fruit.

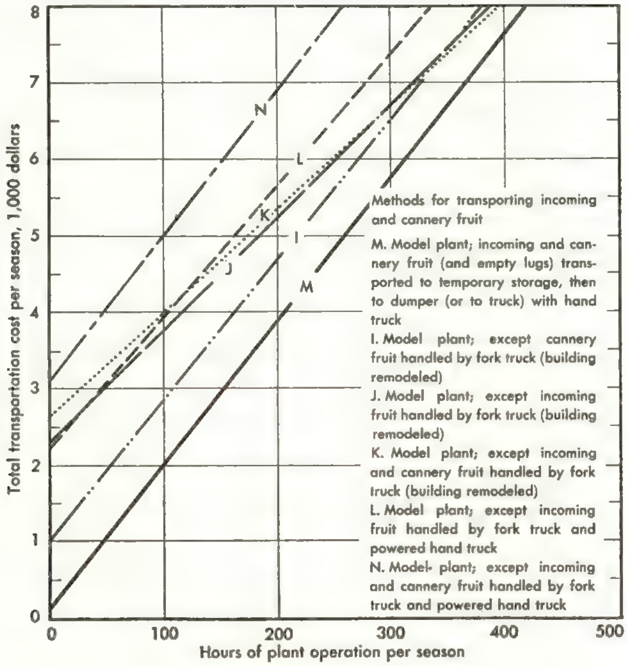


Figure 7. Effect of variations in method of handling incoming fruit and cannery fruit on season total transportation costs in the model hand-truck plant. (Rate of plant operation, 40,000 pounds per hour.)

(J) Model plant--except that the incoming fruit is handled with fork-truck equipment. As in method A, this change requires building alterations to provide a concrete unloading apron. In addition, storage space accessible to the fork truck and access to the dumping station for the fork truck must be provided. The building alterations include removal of the wood floor and supports and the construction of a new concrete slab on the ground, also respacing the roof supports in the receiving area so as to reduce interference with the operation of the fork trucks (Figure 6A).

(K) Model plant--except that both incoming fruit and cannery fruit are handled with fork-truck equipment. Building alterations as described in methods A and B are provided.

(L) Model plant--except that incoming fruit is handled with a combination of fork-truck and powered hand-truck equipment. (The movement of fruit between the highway trucks and the edge of the packing house platform is accomplished by fork truck; movements between the edge of the packing house and points within the house are made with the powered hand truck--see Figure 6B.) A concrete loading apron is required in the receiving area.

(N) Model plant--except that both incoming and cannery fruit are handled with a combination of fork-truck and powered hand-truck equipment as in method L.

Estimates of the fixed costs and the direct costs for each of the above methods are given in Table 9. Note that a new complication has been introduced, a fixed charge for building remodeling. In the preceding studies of cost reduction possibilities, the cost of building changes was not a factor, but the adoption of the changes in the model plant proposed above is conditioned on some building alterations, and the costs of such changes must be included.7/ As a result, the fixed costs are substantially greater than would be necessary to cover the cost of equipment alone.

7/ An important difference should be recognized in the cost problems related to planning new construction in contrast with remodeling existing facilities. In new construction, any available alternative may be chosen without any concern regarding costs for demolition and remodeling. In changes to existing facilities, however, the additional costs of remodeling may be quite important. The present example is approached in terms only of remodeling as no "extra" costs for remodeling are involved in new construction.

TABLE 9

Effect of Variations in Methods of Transporting Incoming Fruit and Cannery Fruit on Transportation Costs in the Model Hand-Truck Plant
(Rate of Plant Operation, 40,000 Pounds per Hour)

Method	Rate of operation per hour	Annual fixed costs			Direct costs per hour
		Equipment[a]	Building and loading apron[b]	Total	
	1,000 pounds	dollars			
(M) Model plant--incoming and cannery fruit (and empty lugs) transported to temporary storage by hand truck, then to dumper (or to truck)	20 40 60 80	60 120 175 230	-- -- -- --	60 120 175 230	10.00 18.85 27.60 36.40
(I) Model plant--except cannery fruit handled by fork truck (building remodeled)	20 40 60 80	435 600 760 925	315 425 575 750	750 1,025 1,335 1,675	10.23 18.40 26.55 34.75
(J) Model plant--except incoming fruit handled by fork truck (building remodeled)	20 40 60 80	960 1,645 2,325 3,010	360 670 935 1,240	1,320 2,315 3,260 4,250	8.35 14.70 21.00 27.30
(K) Model plant--except incoming and cannery fruit handled by fork truck (building remodeled)	20 40 60 80	1,065 1,850 2,640 3,425	470 815 1,160 1,560	1,535 2,665 3,800 4,985	7.80 13.55 19.25 25.00
(L) Model plant--except incoming fruit handled by fork truck and powered hand truck	20 40 60 80	1,140 1,860 2,510 3,320	200 400 615 825	1,340 2,260 3,125 4,145	9.95 17.10 23.75 31.30
(N) Model plant--except incoming and cannery fruit handled with fork truck and powered hand truck	20 40 60 80	1,570 2,735 3,900 5,060	200 400 615 825	1,770 3,135 4,515 5,885	10.95 19.05 27.15 35.27

[a] Estimated as a percentage of replacement cost. See Table 3 for percentage rates.

[b] Computed from estimated cost of constructing concrete paving for loading apron and of remodeling building at annual rate of 8.0 per cent. (Assumed life of building improvements, 20 years--based on assumption of partial expiration of life of original structure. Annual rate then consists of: depreciation, 5.0 per cent; interest, 3.0 per cent, making a total of 8.0 per cent. Note that taxes, insurance, and repair elements of annual charge are not included on the basis that these costs are already covered in the annual charges for the building prior to remodeling.)

Cost comparisons with the various methods can be made from Table 9. With a rate of plant operation of 40,000 pounds per hour, for example, the fixed costs for the hand-truck equipment required in the model plant are estimated as $120. In the model plant, after conversion to the use of fork-truck equipment for handling incoming fruit and cannery fruit--method K--the annual fixed cost for the equipment and building alterations is estimated as $2,665, of which the sum of $815 is the annual charge for building alterations.

Fairly impressive reductions in direct costs result in two instances. With a rate of operation of 40,000 pounds per hour, adoption of fork-truck equipment for handling incoming fruit--method J--would reduce direct costs by $4.15 per hour of plant operation. If this change were extended to include the handling of cannery fruit--method K--the saving would be $5.30 per hour. For the remaining proposals--methods I, L, and N--the indicated reductions in direct costs are relatively small.

Total season costs shown in Figure 7, page 26--for a rate of plant operation of 40,000 pounds per hour--indicate that none of the proposed changes reduce the total plant transportation cost if the length of season is less than about 480 hours. The break-even point between method K and the model plant occurs at about 480 hours of plant operation per season, and for method J the break-even point is about 530 hours per season. For the remaining methods, the reduction in direct costs relative to the model plant is not sufficient to outweigh the higher fixed costs except for a long period of operation per season.

Changes in Plan of Operation for Receiving Incoming Fruit

The effects of two additional types of change in the receiving operations are summarized in Table 10 and in Figures 8 and 9. One change involves a different pattern of movement in the receiving operations, the other, a revision of floor layout in the model plant so as to modify the trucking distances. The changes are as follows.

Direct movement of fruit to dumper.--In the model plant, all fruit received is transported to a temporary storage before going to the dumper. Some direct movement of fruit from the grower's truck presumably is possible in all plants. Such movements are likely to be small, however, if grower's lots must be kept separate. If incoming fruit can be pooled--as, for example, where the incoming fruit is sampled for quality--a substantial proportion of direct movement is possible.

TABLE 10

Effect of Changes in Pattern of Movement and in Transport Distances for Incoming Fruit on In-Plant Transportation Costs

Method	Rate of operation per hour	Hand truck		Fork truck	
		Annual costs for equipment[a]	Direct costs per hour	Annual costs for equipment[a]	Direct costs per hour
	1,000 pounds	dollars			
(M) Model plant--all incoming fruit transported to dumper via temporary storage; total length of transport path: 220 feet in hand-truck plant; 310 feet in fork-truck plant	20	60	10.00	1,410	5.30
	40	120	18.85	2,570	9.20
	60	175	27.60	3,700	13.05
	80	230	36.40	4,850	16.90
(O) Model plant--except one-third of incoming fruit is transported directly to dumper	20	55	9.25	1,330	5.05
	40	105	17.30	2,400	8.70
	60	160	25.30	3,460	12.35
	80	210	33.35	4,525	15.95
(P) Model plant--except total length of transport path is: 150 feet in hand-truck plant; 210 feet in fork-truck plant	20	55	9.40	1,340	5.10
	40	110	17.60	2,425	8.75
	60	160	25.75	3,495	12.45
	80	215	33.90	4,575	16.10
(Q) Model plant--except total length of transport path is: 290 feet in hand-truck plant; 410 feet in fork-truck plant	20	70	10.75	1,490	5.55
	40	130	20.30	2,710	9.65
	60	190	29.85	3,935	13.75
	80	255	39.40	5,160	17.85

[a] Estimated as a percentage of replacement cost. See Table 3 for percentage rates.

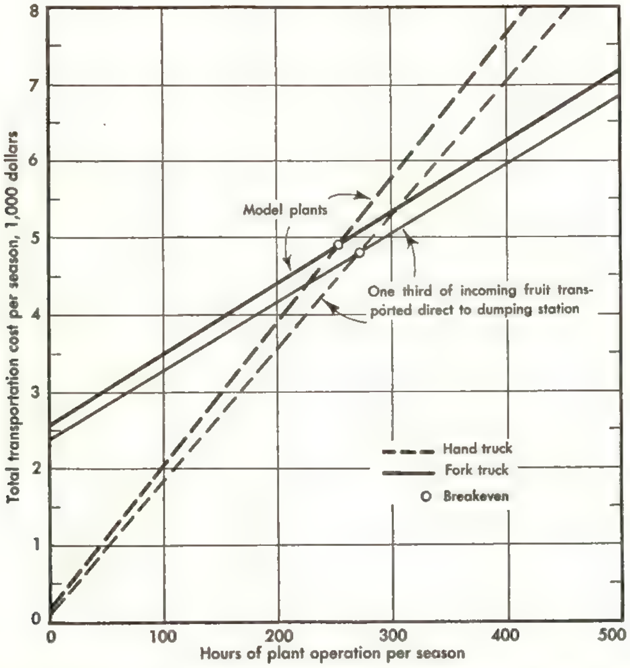


Figure 8. Effect of transporting ⅓ of incoming fruit direct to dumper rather than via temporary storage on total season transportation costs. (Also direct movement for ⅓ of empty field lugs.) (Rate of plant operation, 40,000 pounds per hour.)

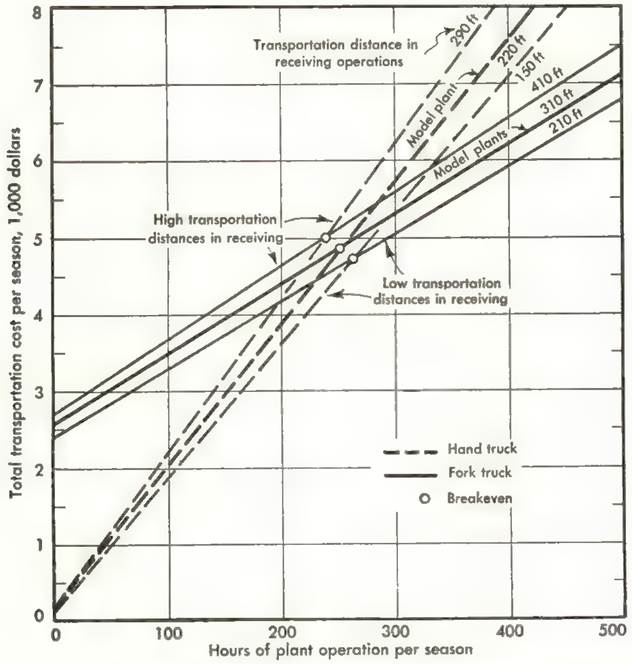


Figure 9. Effect of change in transport distance for incoming fruit on total season transportation costs. (Rate of plant operation, 40,000 pounds per hour.)

The revised costs with hand-truck or fork-truck equipment presented in Table 10 are based on the assumption that one-third of the incoming fruit can be transported directly to the dumper. This change obviously would reduce transportation costs by reducing slightly the transportation distance, but a more important effect is the reduction in the number of "pickup" and "release" elements in the trucking operations.

As indicated in Table 10, this change would permit a slight reduction in fixed costs and a moderate reduction in direct costs. With a rate of plant operation of 40,000 pounds per hour, the saving in direct costs in the hand-truck plant would be $1.55 per hour of plant operation, and in the fork-truck plant the saving would be $0.50 per hour. The cost relationships are illustrated in Figure 8. Note that costs in the model plant are represented by the heavy lines, while costs in the revised plants are represented by the lighter lines. For each type of equipment, the reduction in cost per season for a particular length of season is indicated by the vertical distance between corresponding cost lines. Thus, with 300 hours' operation per season--at a rate of operation of 40,000 pounds per hour--the savings are roughly $480 in the hand-truck plant. Note that a range is possible in the proportion of fruit trucked directly to the dumper. For the conditions represented in Figure 8, this range might be from zero to one-third. The corresponding range in costs for a given length of season is indicated by the vertical distance between the two cost lines for each kind of equipment. Similar relationships are shown for the fork-truck plant.

Relative costs for the two types of equipment also are shown in Figure 8. For a 300-hour season in plants trucking one-third of the incoming fruit directly to the dumper, for example, costs would be lower in the fork-truck plant by roughly $285 per season.

Revise floor layout in receiving area.--In the model hand-truck plant, the total length of trucking path in the receiving operations is 220 feet; in the model fork-truck plant, this distance is 310 feet. These distances are based on a fairly typical layout of space and equipment in the receiving area. In some of the plants studied, the trucking distances in receiving were considerably greater because of faulty layout, and in other plants shorter distances were observed. Trucking distances in receiving could be reduced in the model plant, for example, by using conveyors to transport fruit to the dumper and to transport empty lugs to the storage area after dumping. Further reduction in

trucking distance might be possible if a considerable proportion of the incoming fruit were trucked directly to the dumper. This would reduce the quantity of fruit held in temporary storage, thus permitting a reduction in the dimensions of the storage area.

The effects on transportation costs resulting from differences in layout of the kind outlined above are indicated in Table 10 for two different adjustments. In one case, it is presumed that the receiving area in the model plant can be rearranged so as to make the total length of transportation path in the receiving operations 150 feet in the hand-truck plant in contrast with 220 feet in the model plant. Similar adjustments in the fork-truck plant involve a length of path in the revised plan of 210 feet in contrast with 310 feet in the model fork-truck plant. A second situation is analyzed in which it is presumed that many plants may have a layout in the receiving area that is less efficient than that specified for the model plant. For illustration, the total length of the trucking path in the receiving operations is taken as 290 feet in the hand-truck plant and 410 feet in the fork-truck plant. These changes represent an upward and a downward adjustment in trucking distance for the receiving operations of about one-third in comparison with the model plant.

As indicated in Table 10, the effect of these variations in distance on the fixed costs is not great. An appreciable reduction occurs in the direct costs. Contrasting the plants of high and low trucking distance, the difference in direct costs--at a rate of plant operation of 40,000 pounds per hour--is $2.70 per hour of plant operation in the hand-truck plant; this saving in the fork-truck plant is $0.90 per hour.

The effects on season transportation costs for a rate of plant operation of 40,000 pounds per hour are illustrated in Figure 9. Again, the costs in the model plants are represented by the heavy cost lines. For each type of equipment, the variations in transportation costs associated with the range in trucking distances described above are indicated for a given length of season by the vertical distance between the high and the low cost lines.

Costs in the hand-truck plant can be contrasted with those in the fork-truck plant by comparing appropriate readings from Figure 9. Note that a slight shift occurs in the break-even point, the hours of operation to break even tending to be less as the trucking distance increases. The greater advantage of the fork truck as the distance to be traveled increases reflects its higher load capacity and higher travel speed in comparison with the hand trucks.

The comparisons made in Figure 9 in regard to reductions in the trucking distance do not take into account the cost of physical changes that may be required in the plant layout. Hence, the costs indicated would be appropriate as a guide in planning new facilities. In a situation involving remodeling expense, the relative costs indicated in Figure 9 would be substantially changed.

Change in Load Size

Still another cause of variation in transportation costs is the size of load carried per trip with a given type of equipment. Upward adjustments in load size will reduce the number of trips required and thus reduce costs. The effect of adjustment in load size can be observed by comparing estimates of cost based on the extremes in load size observed and by contrasting these costs with costs in the model plant. The range in load sizes to be considered for the principal transportation jobs is indicated in the following summary.

	Number of lugs or boxes hauled per trip					
	Hand-truck plant			Fork-truck plant		
Operation	Model plant	Minimum load size	Maximum load size	Model plant	Minimum load size	Maximum load size
Receiving:						
Full lugs	6	5	6	36	30	42
Empty lugs	9	8	12	36	30	42
Cannery and cull fruit:						
Full lugs	7	6	7	42	42	54
Empty lugs	7	6	7	42	42	54
Packed fruit:						
Full standard boxes	5	4	5	36	36	36
Empty standard boxes	21	14	24	72	60	96

Estimates of transportation costs for the range in load sizes given above are presented in Table 11 and Figure 10. With a rate of plant operation of 40,000 pounds per hour, the direct costs in the hand-truck plant with minimum load size are $2.85 per hour greater than in the model plant; with maximum load size the direct costs are $0.85 less than in the model plant. In the fork-truck plant, the direct costs--with a rate of operation of 40,000 per hour--are $0.80 per hour greater with minimum load size than in the model plant;

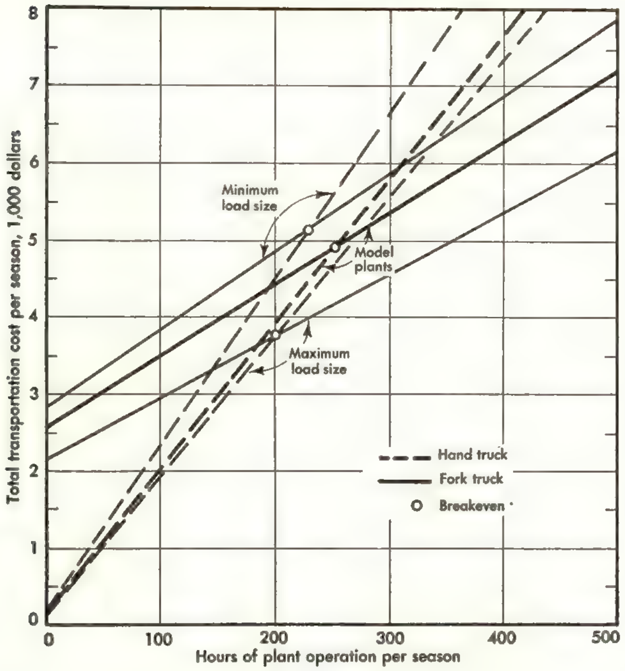
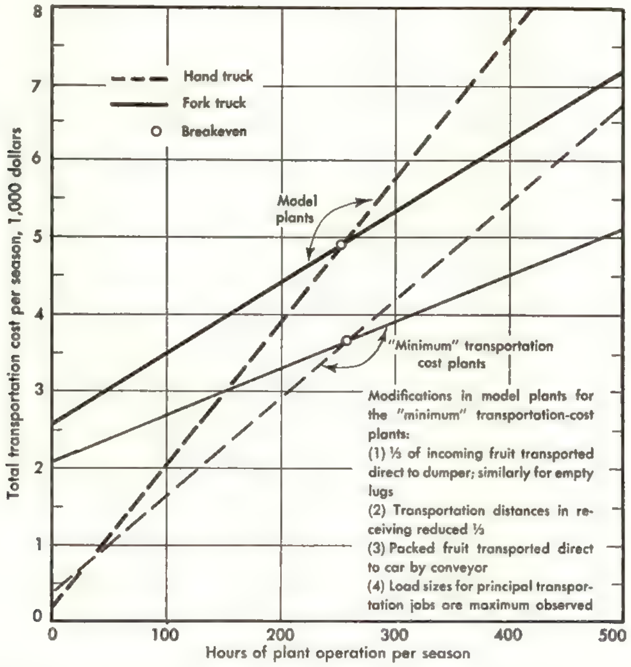


Figure 10. Effect of size of load on season total transportation costs in the model plant. (Rate of plant operation, 40,000 pounds per hour.)



Modifications in model plants for the "minimum" transportation-cost plants:

(1) ⅓ of incoming fruit transported direct to dumper; similarly for empty lugs

(2) Transportation distances in receiving reduced ⅓

(3) Packed fruit transported direct to car by conveyor

(4) Load sizes for principal transportation jobs are maximum observed

Figure 11. Reduction in total season transportation costs in model plants through combining several changes in transportation equipment and methods. (Rate of plant operation, 40,000 pounds per hour.)

with maximum load size direct costs are $1.25 lower than in the model plants. As indicated in Figure 10, a change to the maximum load size in the hand-truck plant does not result in important savings in comparison with the model plant; a change to maximum load size in the fork-truck plant, however, results in significant savings. Comparison of the cost lines with maximum load size in hand-truck and fork-truck plants indicates a reduction in hours of plant operation to break even from about 255 hours per season in the model plant to approximately 200 hours per season with the maximum load size.

TABLE 11

Effect of Size of Load on Season Total Transportation Costs in the Model plant

Method	Rate of operation per hour	Hand truck		Fork truck	
		Annual fixed costs for equipment[a]	Direct costs per hour	Annual fixed costs for equipment[a]	Direct costs per hour
	1,000 pounds	dollars			
Model plant--load sizes as specified in Table	20	60	10.00	1,410	5.30
	40	120	18.85	2,570	9.20
	60	175	27.60	3,700	13.05
	80	230	36.40	4,850	16.90
Model plant--except that the load sizes used on the principal transportation jobs are the minimum observed	20	70	11.45	1,545	5.70
	40	140	21.70	2,835	10.00
	60	205	31.90	4,415	14.25
	80	275	42.10	5,400	18.55
Model plant--except that the load sizes used on the principal transportation jobs are the maximum observed	20	60	9.65	1,210	4.70
	40	110	18.00	2,150	7.95
	60	165	26.40	3,090	11.25
	80	220	34.80	4,035	14.50

[a] Estimated as a percentage of replacement cost. See Table 3 for percentage rates.

Combining Changes for Low-Cost Operation

In the preceding examples, numerous possibilities for reducing the cost of in-plant transportation are demonstrated. In no single case does the indicated saving become large unless the operating season is relatively long. But, consider the possibility of combining several changes. Suppose that the model plants were reorganized along the following lines:

(1) The layout in the receiving area is reorganized to permit a reduction of one-third in the trucking distances for the receiving operations.

(2) One-third of the incoming fruit is transported directly to the dumper.

(3) The packed fruit is transported directly to the car by conveyor.

(4) The maximum load size--as specified in the preceding section--is used on the principal transportation jobs.

The aggregate effect of the above changes on the in-plant transportation costs is summarized in Table 12 and in Figure 11. With a rate of plant operation of 40,000 pounds per hour, the annual fixed costs in the hand-truck plant increase about $255 in comparison with the model plant. This is due to the addition of a packed fruit conveyor. In the fork-truck plant, the changes result in a reduction in annual fixed costs--when the rate of operation is 40,000 pounds per hour--of $480. Direct costs in the hand-truck plant are reduced by $6.15 per hour of plant operation, and in the fork-truck plant, direct costs are reduced by $3.15 per hour. In terms of season total costs, these relationships are illustrated in Figure 11 for a rate of plant operation of 40,000 pounds per hour. Reading from the diagram, the indicated savings for a 300-hour operating season are approximately $1,600 in the hand-truck plant and about $1,400 in the fork-truck plant.

The break-even point between the fork-truck and hand-truck plants under both systems for transporting fruit--as indicated by the intersection of the cost lines--is about 260 hours per season.

EFFECT OF CHANGES IN COST RATES ON TRANSPORTATION COSTS IN MODEL PLANTS

In the preceding discussion, we have analyzed the effect of several different types of equipment and methods of organization on the costs of in-plant transportation. This has been done in terms of cost estimates for a model plant in which the basic jobs to be performed and certain of the cost rates used in the estimates remain unchanged. In the following section, several further variations are considered. These include changes in the rates for wages, annual fixed costs for equipment, and allowances for nonproductive time.

The primary interest in studying these additional variations is to observe their effect on relative transportation costs in the hand-truck and fork-truck plants. Such comparisons will indicate how changes in the cost rates may affect decisions as to the selection of type of equipment.

TABLE 12

Cost Reduction Possibilities through Combination of Several Changes in Transportation Equipment and Methods as Reflected by In-Plant Transportation Costs in Model Plants and in Revised Plants

Method	Rate of operation per hour	Hand truck		Fork truck	
		Annual costs for equipment[a]	Direct costs per hour	Annual costs for equipment[a]	Direct costs per hour
	1,000 pounds	dollars			
(M) Model plant	20	60	10.00	1,410	5.30
	40	120	18.85	2,570	9.20
	60	175	27.60	3,700	13.05
	80	230	36.40	4,850	16.90
(R) Model plant--except for the following: (1) One-third of incoming fruit is transported directly to the dumper; (2) Trucking distances in receiving at minimum; (3) Packed fruit is transported direct to car by conveyor; (4) Load sizes for principal transportation jobs are the maximum observed.	20	160	7.30	1,145	4.05
	40	375	12.70	2,090	6.05
	60	480	18.10	2,910	8.00
	80	580	23.45	3,740	9.95

[a] Estimated as a percentage of replacement cost. See Table 3 for percentage rates.

Changes in Price Level

The preceding analyses are based on specified wage rates and on given prices for equipment. With these cost rates, cost estimates are derived which show for the model plant the hours of operation per season required to break even on transportation costs with hand-truck and fork-truck equipment. What is the effect of a change in the costs rates on the break-even point?

If the prices of equipment and the rates for direct costs--wage rates and equipment operating costs--change in the same proportion, the level of costs will change, but the break-even point will remain as before. If direct costs and equipment costs do not change in the same proportion, however, the break-even point will shift.[8/] This effect is illustrated in Figure 12. Two situations are considered. In one, wages and other operating costs rise 25 per cent above the original levels used in analyzing the model plant. The result is illustrated in Figure 12A. Note that fixed costs--as represented by the intersection of the cost lines with the vertical scale--are unchanged but that the total season costs are higher than in the model plants. The increase in costs is relatively greater in the hand-truck plant than in the fork-truck plant. The hours of plant operation required to break even are reduced from 255 hours per season in the model plants to approximately 230 hours with the higher level of operating costs.

The other side of this question--pertaining to a reduction in operating costs--is presented in Figure 12B. Fixed costs are the same in the model plants and in the revised situation, but operating costs are presumed to decrease 25 per cent. The effect is to reduce the level of cost in both the hand-truck and fork-truck plants but with a relatively greater reduction in the hand-truck plants. Hours of plant operation required to break even are increased from 255 hours per season in the model plants to about 385 hours with the reduced level of operating costs.

8/ This example is concerned with trends in future costs and prices. The effects demonstrated, however, are similar to those applying to the current situation of plants located in an area in which the existing wage level is different from that used in the analysis of the model plants. In other words, if a firm were confronted with the same costs for equipment as those applying to the model plant but could obtain labor for 25 per cent less, the firm's current situation with regard to the model plants is roughly that illustrated in Figure 12B. The reverse situation--fixed costs the same, but direct costs 25 per cent higher--is illustrated in Figure 12A.

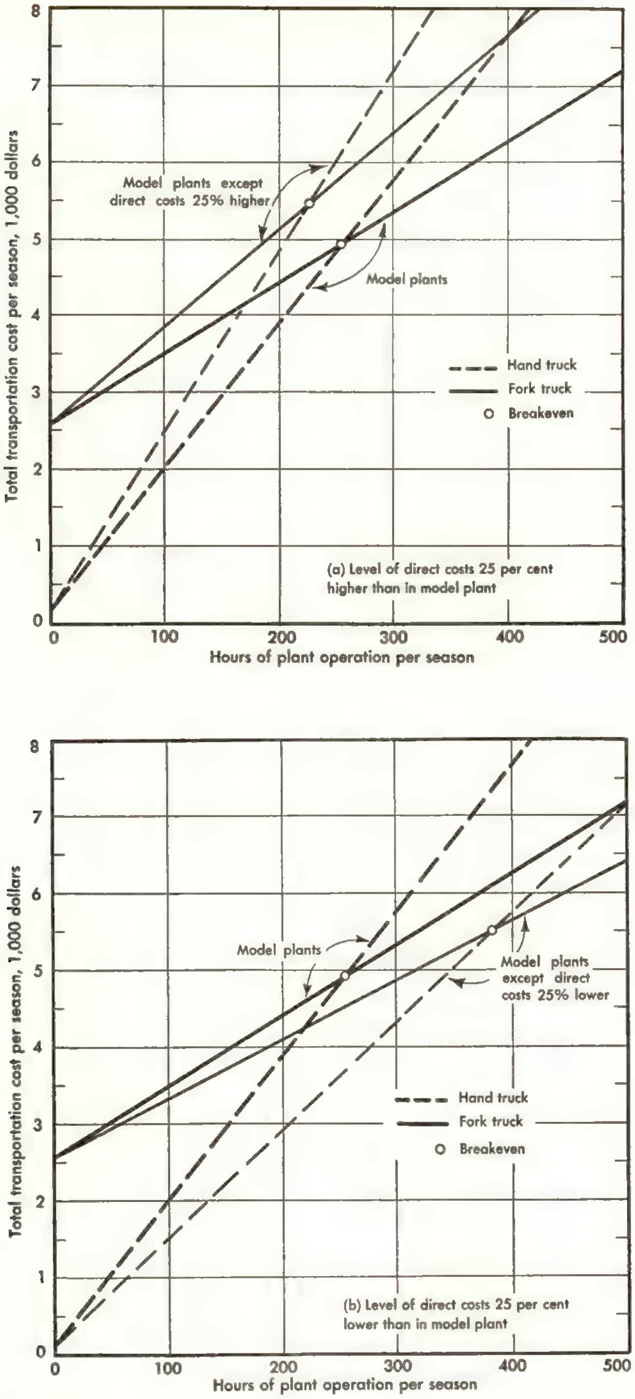


Figure 12. Effect of variation of the level of direct costs on season total transportation costs and in the "break-even" points for the model plants. (Rate of plant operation, 40,000 pounds per hour.) (a) Level of direct costs 25 per cent higher than in model plant. (b) Level of direct costs 25 per cent lower than in model plant

Changes in Proportion of Nonproductive Time

One of the important conditions specified in the model plants is the amount of unavoidable delay, amounting to 15 per cent of the total working time. This proportion, however, applies to an efficient operation, and in most plants, or at least in some years, the proportion of unavoidable delay might easily be much higher. For example, if it is difficult to schedule an even flow of fruit from the orchards, there may frequently be a surplus of labor at the packing house and this would increase the average proportion of idle time. Or uncertainty as to market conditions might result in wide fluctuations in day-to-day shipments yet require the maintenance of a relatively steady work force at the packing house. The effect of variation in the proportion of nonproductive time is illustrated in Figure 13. As in the previous diagrams, the season costs in the model plants are shown by the heavy cost lines. The lighter cost lines represent estimated season costs when operations in the model plants are revised so as to allow for 40 per cent nonproductive time. An increase in the delay time means that more workers are required to do the same amount of work and that a correspondingly greater number of equipment units are required. This is reflected in Figure 13 in the higher level of fixed costs in both hand-truck and fork-truck plants and in the fact that the season costs rise more rapidly in the revised situation than in the model plants. The hours of plant operation required to break even between the two types of equipment are slightly less with the higher proportion of delay.

Effect of Idle Equipment

Still another type of variation might be considered. Suppose that a "design" rate of operation of 40,000 pounds per hour is considered appropriate in selecting the equipment for the packing house. Transportation equipment is purchased on this basis, but because of year-to-year variations in production, a reduced labor force is employed throughout the season in some years. How does this affect the decision as to appropriate type of equipment? The effects of this variation are illustrated in Figure 14. Costs in the model plants are indicated by the heavy cost lines. Costs for a revised situation in which it is assumed that, on the average, 20 per cent of the equipment is idle throughout the season are given by the lighter cost line. In this situation, the fixed costs are charged for the full amount of equipment, but operating costs are less in proportion to the amount of equipment not utilized.

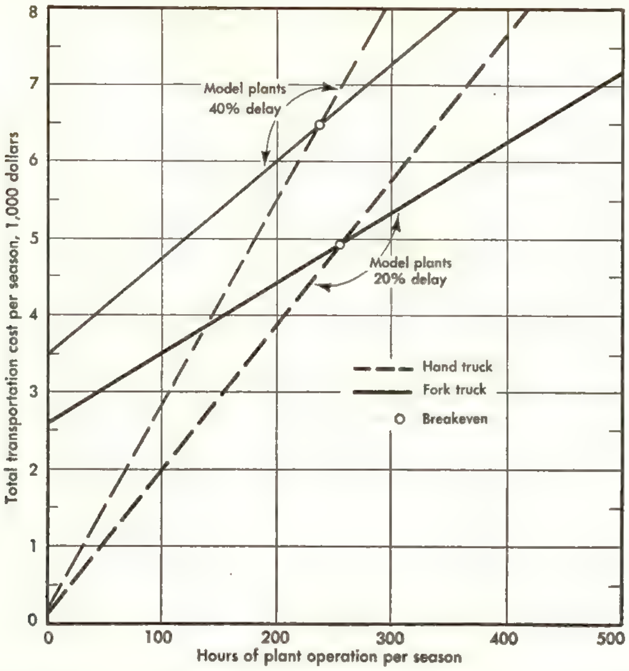


Figure 13. Effect of variation in percentage of nonproductive time on total season transportation costs in the model plants. (Rate of plant operation, 40,000 pounds per hour.)

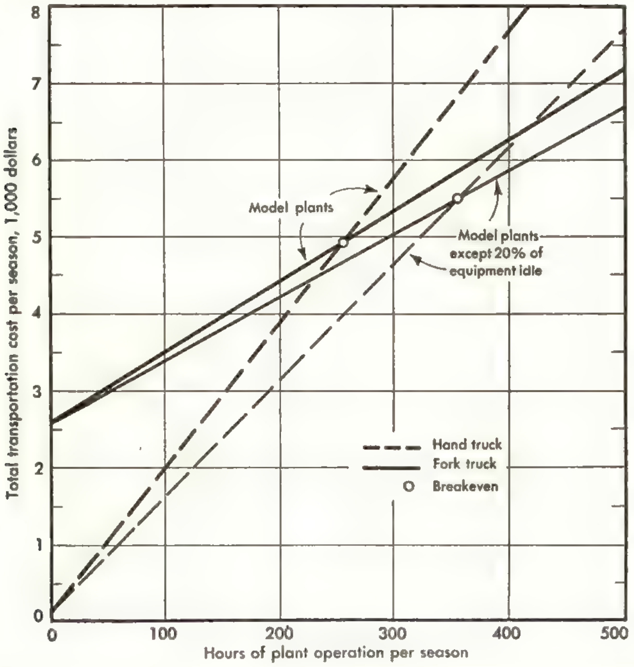


Figure 14. Effect of variation in the average percentage of equipment utilization on total season transportation costs and on break-even point in the model plant. (Capacity rate of plant operation, 40,000 pounds per hour; achieved rate, 32,000 pounds per hour.)

As indicated in Figure 14, the fixed costs are the same in both the model plants and in the new situation. Season costs, however, are less on the average than in the model plants. The hours of plant operation required to break even increase from 255 hours per season in the model plant to about 360 hours per season in the revised situation.

Changes in Estimates of Use Life

One final variation is presented in Figure 15. In the model plants, the use life was taken as 10 years for the fork-truck equipment and 15 years for the hand trucks. These, however, do not represent a sure use life; obsolescense or actual wear-out may compel retirement of the equipment in a shorter time, or the actual use period may be longer than originally estimated. If the actual equipment life should prove to be only five years for the truck equipment and pallets, and the remaining annual charges are unchanged, the annual charge for equipment is 26.5 per cent in contrast with the rates used in the preceding costs estimates.

The effect of this change in the annual cost rate for equipment is reflected in Figure 15. The increase in annual fixed cost for the hand-truck equipment is not large. For the fork-truck equipment, however, a large increase occurs in annual fixed cost. For both types of equipment, the direct costs are unchanged by the shift in basis for estimating fixed costs. The hours of plant operation to break even increase from 255 in the model plants to about 405 in the revised situation.

Similar comparisons on the basis of a 15-year life instead of a 5-year life indicate the break-even point between the fork-truck and hand-truck equipment in the model plants to be about 200 hours per season (see Figure 15).

OWNERSHIP COSTS VERSUS RENTAL COSTS FOR FORK-TRUCK EQUIPMENT

In the preceding examples, transportation labor requirements are much less with fork-truck equipment than with hand trucks. In many instances, however, the high fixed costs associated with the fork trucks and a short operating season make the use of the fork-truck equipment uneconomical. Since the fork truck is mobile and easily moved, could this situation be improved if the equipment were rented rather than owned? A graphic answer to this problem is given in Figure 16. Three ownership cost lines are shown in this diagram. The lower line gives the annual fixed cost per equipment unit as $435, based on a 15-year use life; the middle line indicates an annual fixed cost

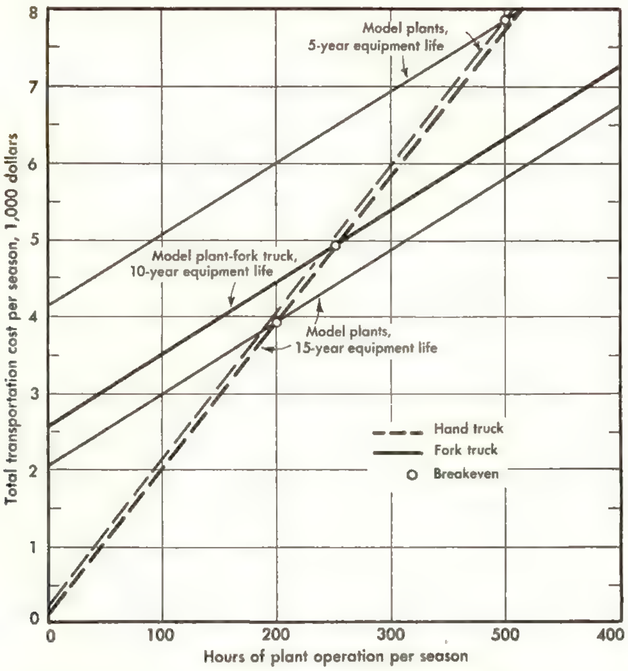


Figure 15. Effect of variation in depreciation rate for transportation equipment on total season transportation cost and on break-even point. (Rate of operation, 40,000 pounds per hour.)

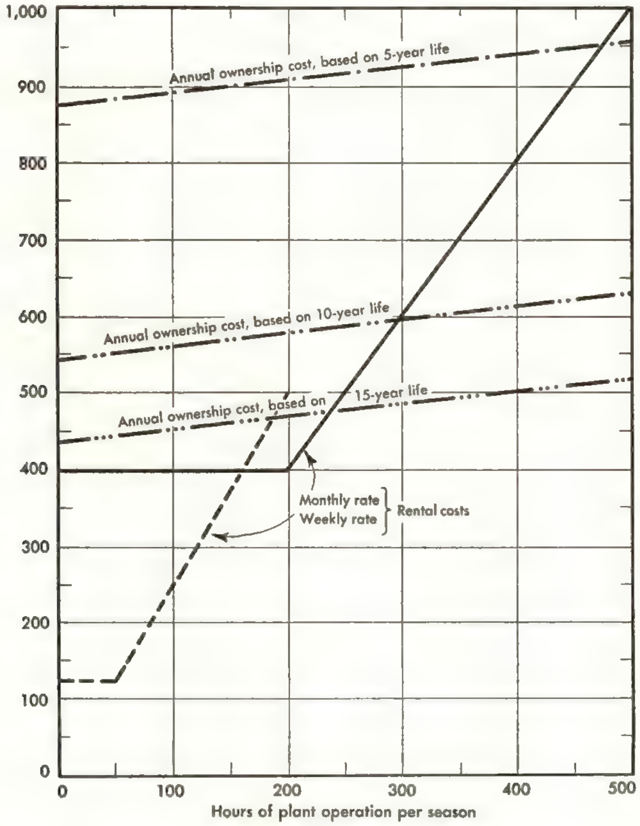


Figure 16. Effect of length of plant operating season on relative costs of ownership and rental for 4,000 pound capacity, gas-engine fork truck.

of $545, based on a 10-year life; and the upper line indicates an annual fixed cost of $875, based on a use life of only five years. The slight upward slope of these cost lines reflects the increase in direct repair costs as hours of use increase.

Typical rental costs at the 1950 price level are also represented in Figure 16. Rental costs are shown in relation to a 50-hour work week, or a 200-hour work month. For short rental periods, the season rental cost rises at the rate of $125 per week, and for longer periods, at the rate of $400 per month.[9] Rental cost at the monthly rate is represented by a horizontal line for less than 200 hours' use per season--indicating a minimum charge for one month--and for longer periods, the monthly rental cost rises at the rate of $400 per 200-hour work month. These rentals are approximate, and some variation could be expected with respect to a particular situation. The rates cover the equipment cost only and do not include the cost of fuel or the wage of the operator. On this basis the season rentals are comparable to the annual fixed costs of equipment ownership.

For periods less than one month--assuming 200-hours of operation per month--rental costs are lower than any of the three estimates of annual fixed costs. For longer periods of use per year, rental and ownership costs appear to break even at about 240 hours of use per season when a 15-year life is assumed for the equipment; the break-even point is at about 300 hours of use per season when a 10-year life is assumed for the equipment and is at about 475 hours of use per season when the use life of the equipment is taken as five years. These estimates of break-even point are guides in deciding the question of ownership or rental of the fork-truck equipment. They might be applied to the entire quantity of equipment required. Or, if a plant customarily experienced a relatively long season having a short period of peak operation, the indications as to break-even point might be significant in regard to equipment requirements for the peak period only.

9/ The rental rates quoted do not include a limitation on hours of use during the rental period, but the weekly or monthly use indicated is fairly representative of actual conditions. Other assumptions in regard to hours of use per rental period would yield different results, but Figure 16 could easily be modified accordingly.

OTHER FACTORS AFFECTING CHOICE OF EQUIPMENT

In the preceding discussion, many factors affecting the costs of in-plant transportation have been analyzed. Although such analyses bear directly on the key question of relative costs with different types of equipment, several other considerations are important. The following are noted in regard to fork-truck and hand-truck equipment.

(1) The time required to unload the grower's truck and to reload it with empty lugs may be considerably less with fork-truck equipment than with hand-truck equipment. In a typical situation, one worker with a hand truck would require about 36 minutes to unload 216 field lugs; with fork-truck equipment, he could complete this task in about 13 minutes. If two workers were assigned to each grower's truck, the elapsed time in unloading with each type of equipment would be reduced by roughly one-half, making the elapsed time with hand trucks about 18 minutes per 216-lug load and with fork trucks about 7 minutes.

While a difference in unloading time of this amount would not directly affect the in-plant transportation costs, it might be of considerable importance to the grower. For example, if a grower were to haul 5 loads per day to the packing house, the saving in time--assuming two workers per load with either type of equipment and 216 lug loads--would be 55 minutes per day, or nearly one hour of hauling time. The estimated saving might be considerably greater if the chance arrival of several growers at the packing house at the same time were to develop a backlog of grower's trucks to be unloaded. Differences in unloading time, while affecting the grower most directly, may have an important bearing on the equipment chosen for the packing house unloading operations.

(2) The capacity of fork-truck equipment to handle a temporary overload of the kind mentioned above probably is greater than that of the hand-truck equipment. Workers with hand trucks undoubtedly can accelerate their working pace temporarily but would not be able to maintain the more rapid pace for as long a period as would be possible with mechanical equipment. In this respect the fork-truck equipment would be more adaptable to variations in work load than the hand-truck equipment.

(3) Under typical conditions, the number of truckers required in a hand-truck plant is about three times that required in a fork-truck plant. This may be an important consideration in a period of labor shortage. In any event, to have fewer workers would simplify the problem of supervision.

The foregoing, while not entering directly into the cost calculations, are important considerations. In some instances they might be regarded as sufficiently important to warrant selection of mechanical equipment in situations where it may not be clearly justified on the basis of in-plant transportation costs alone.

SUMMARY

Studies of in-plant transportation in a number of California packing houses indicated labor costs for transportation with mechanized equipment--for example, fork trucks or conveyor systems--ranging from $0.209 to $0.338 per 1,000 pounds of fruit run; in nonmechanized plants--using hand trucks--the range was $0.645 to $1.140 per 1,000 pounds of fruit run. These figures suggest that, in some plants, substantial reductions in transportation costs are possible.

Two types of widely used equipment--hand trucks and fork trucks--require different types of building construction for the packing house. In terms of estimated annual building costs, however, there is little difference in building costs with the two types of equipment, and this factor may be ignored in analyzing transportation costs.

Because of the many variations between plants, interplant comparison of actual costs may easily be misleading. Relative costs with different types of equipment or methods may be shown more clearly by comparison of estimated costs in typical or "model" plants operating under standardized conditions. These estimates include direct operating costs, such as labor and power and fixed costs for equipment. In general, mechanization results in higher fixed costs while direct costs are reduced.

Whether it is economical to mechanize the transportation operations depends primarily on the length of season. For example, in a model or "standardized" plant in which the transportation work is performed either with hand-truck or fork-truck equipment, the season transportation costs "break even" at about 255 hours' operation per season. For shorter seasons the transportation costs are less in the nonmechanized, hand-truck plant than in the fork-truck plant; for seasons longer than about 255 hours, this relationship is reversed.

Studies of variations in transportation methods in the "standardized" hand-truck or fork-truck plants indicate that reductions in transportation costs in these plants are possible. The more promising changes include the

following: transporting packed fruit directly to the car with a power conveyor, rather than by truck; transporting a portion of the incoming fruit directly to the dumper, rather than via a temporary storage; using the maximum load size for truck operations, arranging the plant layout so as to minimize transportation distances. In hand-truck plants, the direct costs of transportation in the receiving operations and in handling cannery fruit may be reduced by substituting fork-truck equipment or by using a combination of fork-truck and powered hand-truck equipment. The reduction in direct costs is not great enough, however, to offset the increased fixed costs unless the operating season is relatively long--480 or more hours of plant operation per season.

The level of costs and the break-even point between costs with mechanized and nonmechanized equipment are affected by the level of wages and other cost rates. Such effects are illustrated for variations in the level of wages and other direct costs, for variations in the proportion of nonproductive time and in equipment utilization, and for differences in the rate of equipment depreciation.

Mobile equipment, such as a fork truck, is easily available on a rental basis. For a long season operation, rental costs may exceed the fixed costs of ownership. If the season is short, however, it may cost less to rent than to own such equipment. In this event the use of mechanized equipment may be profitable, even for short season operations.

While costs are a primary consideration in the choice of equipment, other factors may affect the selection of equipment or method. Thus, in comparing hand-truck and fork-truck equipment, the greater speed with which grower's trucks may be unloaded and the reduced number of workers required with fork-truck equipment may indicate its use in situations where it may not be clearly justified on the basis of costs alone.

Analysis of the costs of in-plant transportation may be desirable in connection with the planning of new facilities with several methods equally available. Or, the problem may involve changes to an existing plant which require the substitution of new equipment or methods for those presently in use. In either case, the data given in regard to labor and equipment requirements, and with respect to the costs of these factors, can be used to estimate transportation costs with alternative methods. Such estimates are important guides in the selection of the most appropriate method and equipment.

APPENDIX A

ESTIMATING REQUIREMENTS FOR TRANSPORTATION CREW AND EQUIPMENT, THE MODEL PLANT

The cost comparisons given in this report for different methods of in-plant transportation are based on estimates of crew and equipment requirements in a typical or "model" plant. The model represents relatively efficient plant organization rather than an "ideal," optimum efficiency plant. The arrangement of packing equipment, storage areas, and work spaces in the model plant follows the pattern indicated in Figure 3, and a detailed specification with respect to in-plant transportation is given for two types of transportation equipment--fork trucks and hand trucks--in Table A.

As indicated in Table A, five groups of transportation operations are involved. These are receiving incoming fruit, transporting packed fruit, transporting cannery and cull fruit, transporting shook and boxes, and miscellaneous transportation jobs. Each of these job groups includes several separate operations. Receiving, for example, includes unloading the grower's truck and transporting the fruit to a temporary storage; transporting full lugs from the temporary storage to the dumper; transporting empty lugs from the dumper to an empty lug storage; and loading empty lugs on the grower's truck.

The proportion of fruit packed is specified as 75 per cent of the total receipts, with 25 per cent diverted to cannery use and to culls. In supplying empty boxes to the packers, it is specified that 80 per cent of the boxes are moved by gravity conveyor directly from the boxmaker to the point of supply to the packers, while the remaining boxes are transported to a temporary storage and later transported to the packer supply point. Only the latter quantity of boxes is considered in estimating transportation costs for the model plant.

The average length of haul and size of load is specified for each transportation task. For example, in unloading the grower's truck, the average length of haul is 50 feet in the hand-truck plant, and the load size is 6 lugs; in the fork-truck plant, the trucking distance is 100 feet, and the load size is 36 lugs.

An additional operation--not shown in Table A--is included in the model. This is the setoff and stacking of packed fruit after lidding. Although not ordinarily regarded as a transportation job, consideration of this operation is necessary in analyzing transportation costs if a conveyor is used to transport packed fruit.

TABLE A

Transportation Jobs, Distances, and Size of Load in a Model Plant

Transportation task	Percentage of total volume run	Average distance transported[a]		Size load per trip	
		Hand truck	Fork truck	Hand truck	Fork truck
	per cent	feet		boxes	
Receiving					
Unload grower's truck and transport to temporary storage	100	50	100	6	36
Transport full lugs from temporary storage to dumper	100	40	50	6	36
Transport empty lugs from dumper to empty lug storage	100	100	120	9	36
Load empty lugs on grower's truck	100	30	40	9	36
Packed fruit					
Transport from setoff to temporary storage	75	35	35	5	36
Transport from temporary storage to highway truck or railway car	75	40	50	5	36
Cannery and cull fruit					
Unload empty cannery lugs and transport to temporary storage	25	35	40	7	42
Transport empty lugs from temporary storage to cannery setoff	25	50	60	7	42
Transport full lugs from setoff to temporary storage	25	40	40	7	42
Transport full lugs from temporary storage to cannery truck	25	35	50	7	42
Shook and boxes					
Transport shook from temporary storage to boxmaker	75	40	50	40[b]	200[b]
Transport boxes to temporary storage; thence, to box liner	15	50	60	21	72
Miscellaneous					
Transport lids and wraps, unload shook, move pallets, etc.[c]					

(Continued on next page.)

Table A continued.

a/ Transport distances for each task are taken as constant for a range in plant capacity of 20,000 to 80,000 pounds per hour. This is based on the fact that in-plant transportation consists largely of inward and outward movements of materials (movement at right angles rather than parallel to the building walls) around the edges of a "center core" of floor area containing the packing equipment (see Figure 3). Hence, for a wide range in plant capacities, the changes in trucking distances are relatively small. If full account were taken of these differences, downward adjustments in estimated costs would occur. Costs for rates of operation of 60,000 pounds per hour would be about 2 per cent less than indicated. Similarly, the costs for rates of 40,000 pounds per hour would be about 4 per cent less and for 20,000 pounds per hour, about 6 per cent less than indicated.

b/ Standard box equivalent of quantity of unassembled shook transported per trip.

c/ Estimated as 10 per cent of total trucking requirements, exclusive of "miscellaneous."

Finally, the net weights selected as appropriate for the various containers are as follows:

Container	Pears	Apples
	net weight, pounds[a]	
Standard packed box	48	42
Field lug	44	40
Cannery or cull lug	46	40

a/ Net weights for Bartlett pears and Gravenstein apples. For other varieties, the net weights may be slightly different.

The above specification of the transportation operations forms the basis for estimates of transportation costs in hand-truck and fork-truck plants that are essentially alike, except for the type of transportation equipment. Variations in the basic methods can be introduced and their effects on costs studied.

Requirements for Trucking Operations

The amount of trucking labor and equipment required in the model plant depends on the type of equipment used, given the size of loads and trucking distances specified. For each trucking task, the initial step is to estimate the time required per trip. This estimate must be made in two parts. One part includes the operations performed on each trip regardless of the distance traveled; the other part is the time spent in travel. This division of time is as follows:

(a) engage load, back and turn;
(b) "spot" load at delivery point, release and turn;
(c) travel with load to delivery point; and
(d) travel without load to pickup point.

Thus, operations (a) and (b) are on a per-trip basis, while operations (c) and (d) are related to the distance traveled per trip. Time requirements expressed on this basis for hand-truck, fork-truck, and powered hand-truck equipment are summarized in Table B. These time requirements are based on a round trip from pickup to delivery point and return.

The use of the data in Table B to estimate labor and equipment requirements is illustrated as follows for the job of transporting packed fruit from the lidder to temporary storage in the model plant: Suppose that fruit is packed in standard boxes of 48 pounds net weight each at the rate of 30,000 pounds per hour and that the transportation equipment consists of hand trucks.

TABLE B

Time Requirements for Transportation with Warehouse-Type Trucks, Minutes per Round Trip[a]

Type of equipment and job	"Turn-around" time	Travel time[b]
	minutes	
HAND TRUCK		
Unload highway truck[c]: full field lugs, to storage or dumper; empty cannery lugs, to storage or cannery setoff	0.311	0.00659 D
Transport to highway truck or car[c]: empty field lugs, from storage or dumper; full cannery lugs from cannery setoff or storage; packed fruit, from lidder-setoff or from storage	0.339	0.00659 D
Transport from storage: full field lugs to dumper; empty cannery lugs to cannery setoff, empty packing boxes to box liner	0.274	0.00659 D
Transport to storage:		
Packed fruit from lidder; full cannery lugs from cannery setoff	0.292	0.00676 D
Empty packing boxes from boxmaker	0.274	0.00676 D
Empty field lugs from dumper	0.236	0.00676 D
FORK TRUCK		
Unload highway truck:		
Full field lugs to storage or dumper	0.805	0.0050 D
Empty cannery lugs to storage or cannery setoff	0.760	0.0050 D
Load highway truck:		
Empty field lugs from storage or dumping station	0.617	0.0050 D
Cannery lugs from storage or cannery setoff	0.765	0.0050 D
Transport from storage:		
Packed fruit to car; full field lugs to dumper	0.688	0.0050 D
Empty cannery lugs to cannery setoff; shook to boxmaker; empty packing boxes to packer supply point	0.538	0.0050 D
Transport to storage:		
Empty field lugs from dumper; empty packing boxes from boxmaker	0.513	0.0050 D
Packed fruit from lidder setoff; cannery fruit from cannery setoff	0.688	0.0050 D
POWERED HAND TRUCK		
Transport to and from storage points: field lugs, cannery lugs, packed fruit; shook; empty packing boxes	0.690	0.0053 D

(Continued on next page.)

Table B continued.

a/ Trucking time per round trip is expressed in terms of the type of equipment used and the distance traveled. The time required may also be affected by the size of load, with increased labor requirements for excessively large loads. For the range of load sizes observed in this study, the variation in time required due to size of load was not large, and the effect of this factor has been ignored.

b/ D = one-way distance in feet.

c/ Distance measured from delivery or pickup point in packing house to edge of truck.

As specified in Table A, the load-size is five boxes, and the transportation distance, 35 feet. From Table B the time required per trip would be:

	Man-minutes
"Turn-around" time	0.292
Travel time = 35 x 0.00676	0.237
Time per trip	0.529

With 240 pounds transported per trip, 4.17 trips are required to transport 1,000 pounds of fruit; the labor required is 2.20 man-minutes per 1,000 pounds. To transport 30,000 pounds of fruit per hour to the temporary storage would thus require 66 man-minutes, or slightly more than the capacity output of one trucker.

An estimate of labor and equipment requirements for the entire plant is made by a similar procedure. First, the requirements for each element of the transportation operations specified in Table A are estimated. The sum of the labor requirements for individual operations then represents the requirements for the entire plant. The results of applying this procedure to the model hand-truck plant are summarized in Table C. The transportation labor requirements indicated are for a rate of plant operation of 40,000 pounds per hour, of which 30,000 pounds per hour are packed, and the remainder consists of cannery fruit and culls.

The estimate of labor requirements for each job group is given in Table C for a rate corresponding to 1,000 pounds of fruit per hour in the particular job group. These labor requirements are then adjusted according to the proportion of the total fruit run that is handled in each category. For the model plant, these proportions are as follows: for the receiving operation, 1.0; for cannery and cull fruit, 0.25; and for packed fruit, 0.75. The appropriate proportion, when applied to the labor requirements per 1,000 pounds in a job category, gives an estimate of labor requirements that is related to total fruit run. In the above example, the sum of such estimates for individual operations is 13.8 man-minutes per 1,000 pounds of fruit run, and with the addition of miscellaneous transportation jobs, the total labor requirements are 15.2 man-minutes per 1,000 pounds run. Using a rounded figure of 20 per cent total unproductive time, the gross labor requirement is 19.0 man-minutes per 1,000 pounds of fruit received.[10/] To perform the trucking work

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[10/] For an explanation of the basis for this percentage, see page 13 of this report.

TABLE C

Estimated Net Trucking Labor Requirements in the Model Hand-Truck Plant--Rate of Operation, 40,000 Pounds of Fruit Run per Hour

Operation	Time required per 1,000 pounds of fruit	Proportion of each category to total run	Time required per 1,000 pounds of fruit run
	minutes		minutes
1. Receiving: unload grower's truck and transport full field lugs to dumper via temporary storage; transport empty lugs to grower's truck via temporary storage	8.12	1.0	8.12
2. Cannery and cull fruit: unload truck and transport empty lugs to cannery station via temporary storage; transport full lugs to truck via temporary storage	6.96	0.25	1.74
3. Packed fruit: transport packed fruit to truck or car via temporary storage	4.73	0.75	3.55
4. Shook and boxes: transport shook to boxmaker and empty boxes to storage and return	0.52	0.75	0.39
5. Subtotal time per 1,000 pounds run			13.80
6. Miscellaneous: transport lids and wraps, unload shook, etc., 10 per cent of operations 1 to 4	--	--	1.4
7. Total transportation labor per 1,000 pounds run			15.2

involved in this example then requires a total of 760 man-minutes of labor per hour. This is equivalent to the employment of about 13 truckers.[11]

Requirements for Setoff Operation

A similar, although much simpler, procedure is followed in estimating the requirements for setoff labor. Studies of this job in several packing houses indicate the net productive time required per standard box to be as follows:

Grasp box on conveyor, turn and stack on floor to a height of 4 or 5 boxes (or the reverse operation) . .	0.105 minutes per standard box

To set off and stack 1,000 pounds of fruit in standard boxes require (1,000/48) x 0.105 = 2.19 man-minutes. Adding an allowance of 20 per cent for nonproductive time--as with the trucking labor--makes the gross labor requirement 2.73 man-minutes per 1,000 pounds of fruit setoff. To set off 30,000 pounds of fruit per hour would require (30 x 2.73) = 82 man-minutes per hour. In this case the labor actually supplied would be two workers, unless it were possible to use part of the setoff worker's time on some other operation.

Estimates of Transportation Crew and Equipment

Bringing together the estimates of labor requirements for the above example, the "transportation" crew and equipment would consist of two setoff men, 13 hand truckers, and 13 hand trucks. Equipment and labor costs for this crew may be estimated in the manner described on pages 7 to 14 of this report.

Similarly, transportation crew and equipment could be estimated for other rates of operation in the model plant or for operation with fork-truck equipment. Moreover, the basic requirements for trucking and setoff operation could be used to estimate requirements for plants differing in layout and specification from the model plant.

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[11] In regard to the crew organization required for in-plant transportation, it is clear that crew size must be changed in whole units. One may have 12 truckers, or 13 truckers, but not 12½ truckers. This "indivisibility" of workers and equipment means that as crew size in different plants is adjusted to the work load the costs change in discontinuous steps. Note, however, that these step adjustments do not occur at precise points as the rate of output changes but occur over a "zone" of output rates. In other words, relatively more workers are employed in some plants than would be indicated by the analysis. In other plants more intensive use than is indicated in the analysis may be made of the transportation equipment--for example, by working overtime hours, or by reducing the proportion of nonproductive time. This degree of flexibility is roughly accounted for in the estimates of transportation costs given in this report by basing the cost comparisons on the average cost at each step interval.